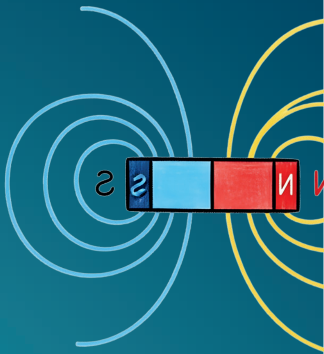
Home
STEAM Lab



Book of Experiments #2

Electricity-Magnetism

For more experiments,
video instructions and
photos, scan the QR.

This book series is inspired by Arvind Gupta's Toys from Trash (www.arvindguptatoys.com), and grew from outreach events hosted by the Bhaktivedanta STEAM School of Excellence (Kanpur) in collaboration with the Indian Institute of Technology Kanpur. Arvind Gupta is a science educator, toy inventor and author. He graduated from IIT Kanpur in 1975 and received the Padma Shree from the Government of India in 2018. This book is prepared by Prof. Kunal Mooley and Kritika Awasthi from IIT Kanpur, and it is meant for educational and outreach purposes only.

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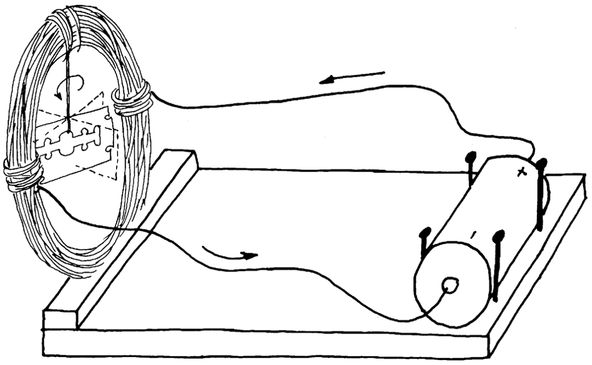

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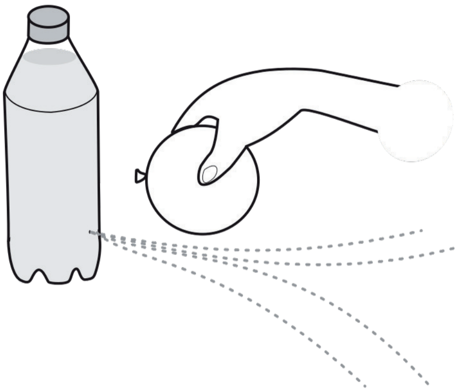
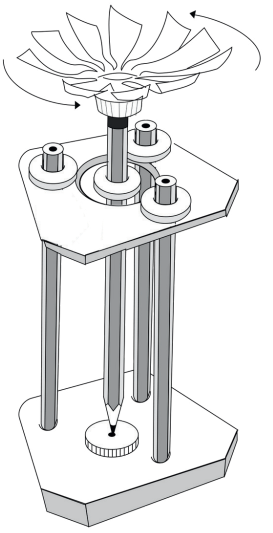
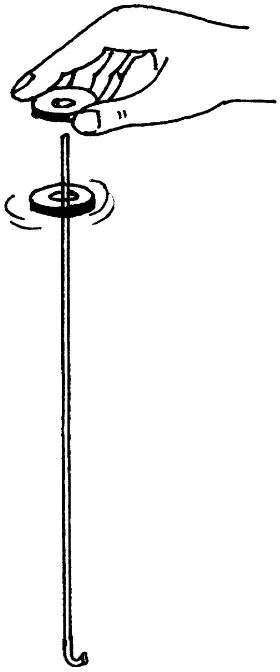




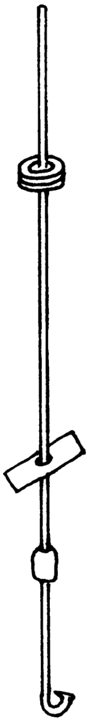
In the spirit of "toys from trash" most of the materials required for the experiments in this book can be found at home. Other simple items like battery/holder, wires, magnets, light bulb, toy fan and motor can be easily purchased from a nearby hardware store or online stores (example: Electronic Spices Science Experiment Kit Pullox Ferrite magnets from Amazon.in).

1. Spooky Spoke

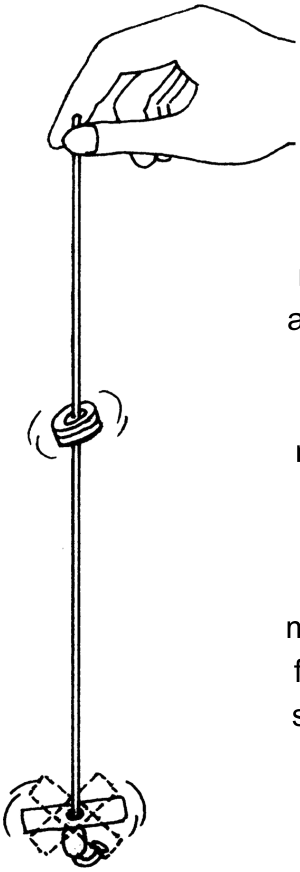
You will require two ring magnets, a cycle spoke, a bead and some card sheet to do this experiment.



1. First put the ring magnets in the spoke. Hold the spoke loosely at the top end. You will be amazed to see the magnets go whirling down the spoke. The magnets speed up as they come down and this vibrates the lower end of the spoke.

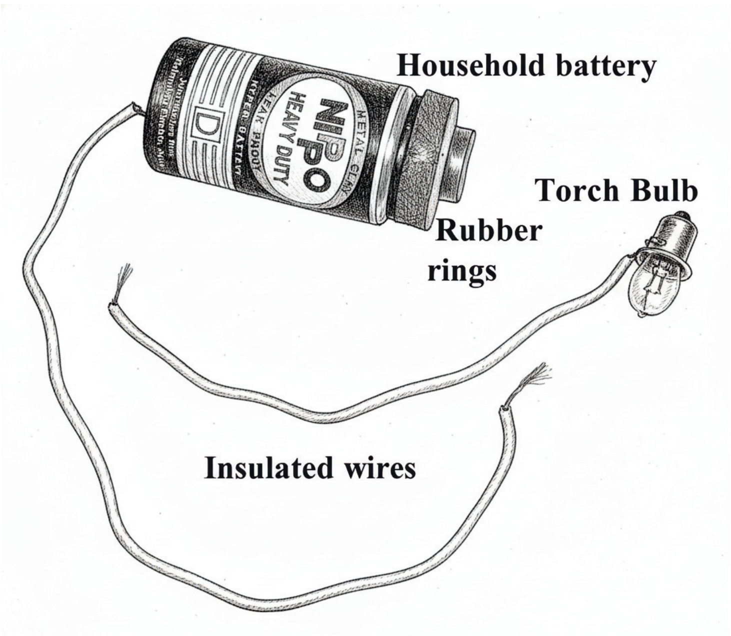


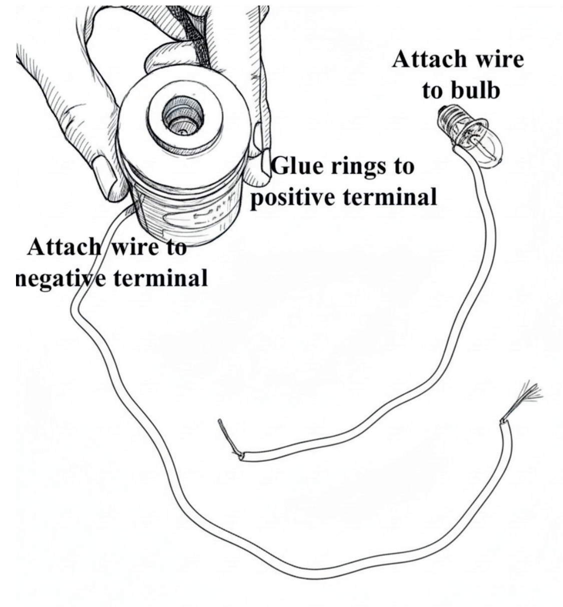
2. Place a bead (to reduce friction) and a card fan on the lower end of the spoke. The bead enables the fan to rotate freely. Now place the magnets on the top end and hold the spoke loosely at the top.

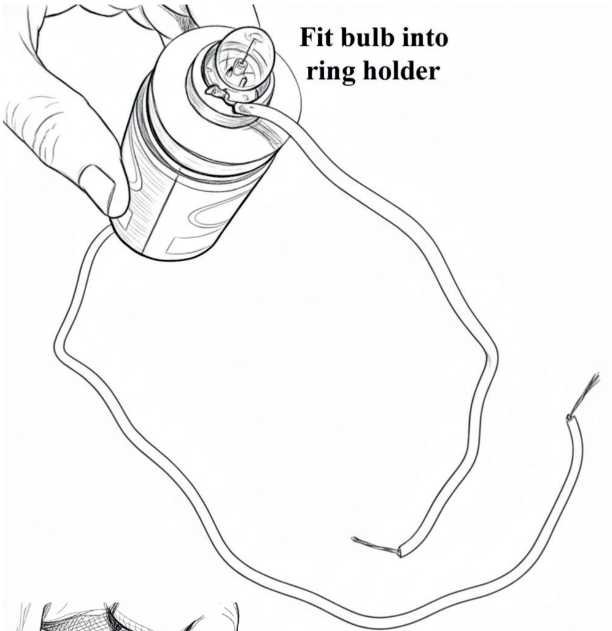


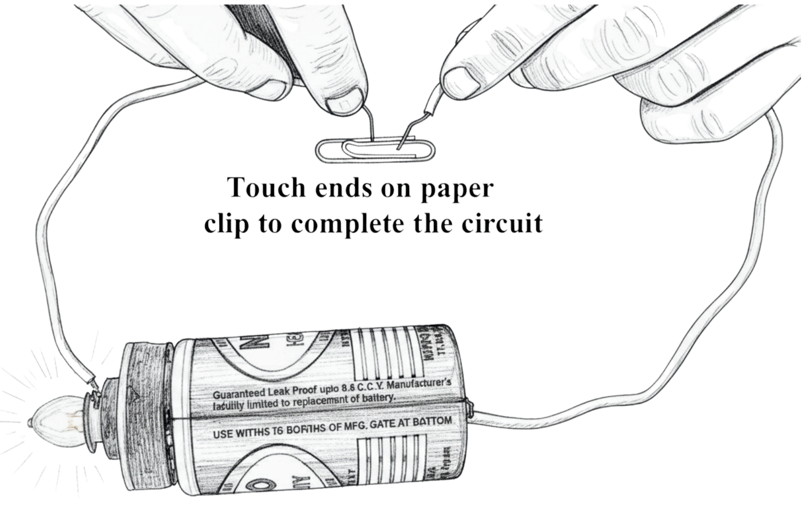
3. As the magnets rotate and come down, the spoke vibrates. This makes the card sheet fan turn round-and-round. Do the magnets and the fan rotate in the same direction?

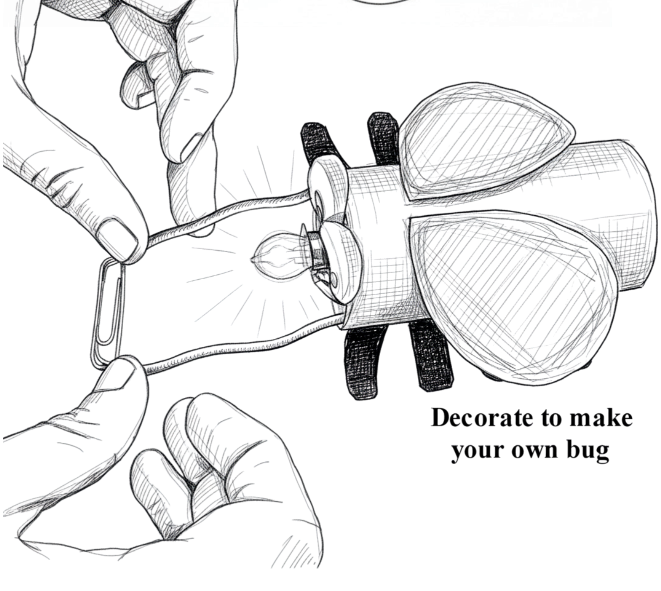
2. NOSE BUG

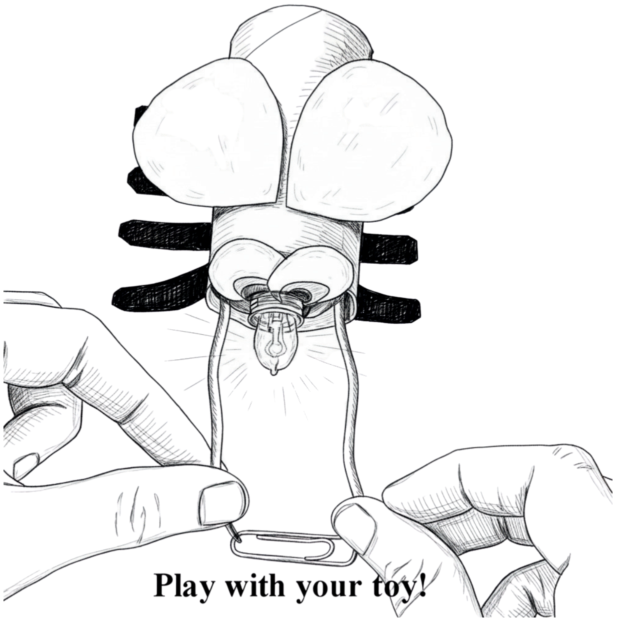

Household battery
Torch Bulb
Rubber rings
Insulated wires


Attach wire to bulb
Glue rings to positive terminal
Attach wire to negative terminal

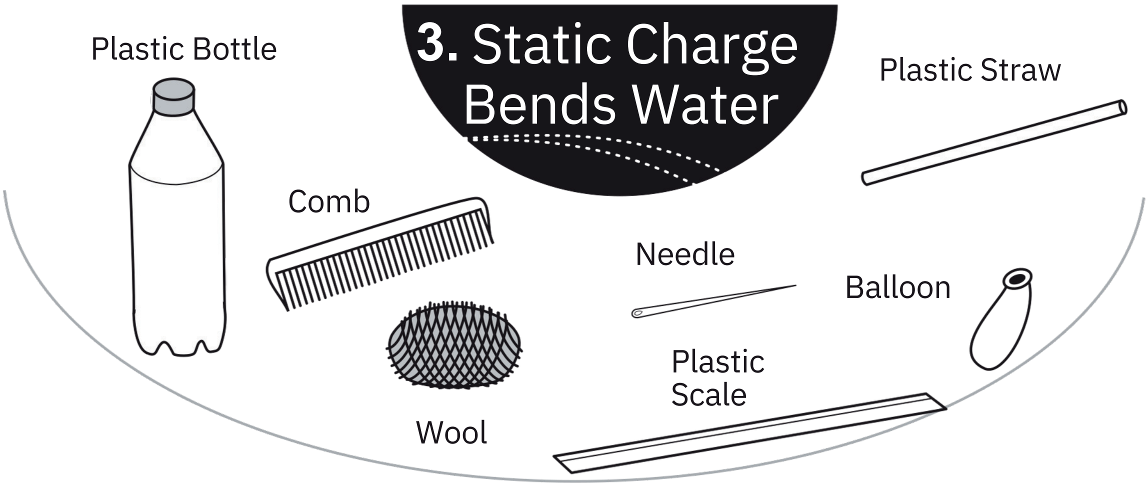

Fit bulb into ring holder


Touch ends on paper clip to complete the circuit


Decorate to make your own bug


Play with your toy!

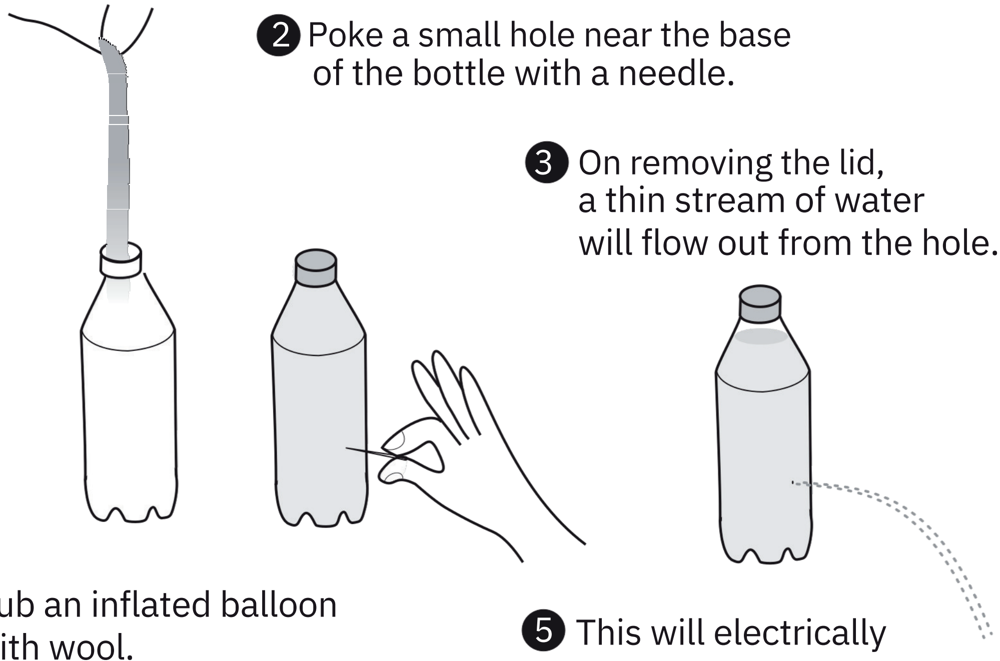
3. Static Charge Bends Water


Plastic Bottle
Comb
Wool
Needle
Plastic Straw
Balloon
Plastic
Scale

❶ Fill bottle with water and screw the lid.

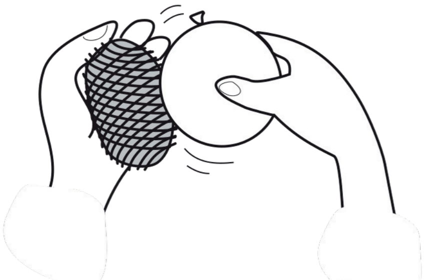
❷ Poke a small hole near the base of the bottle with a needle.

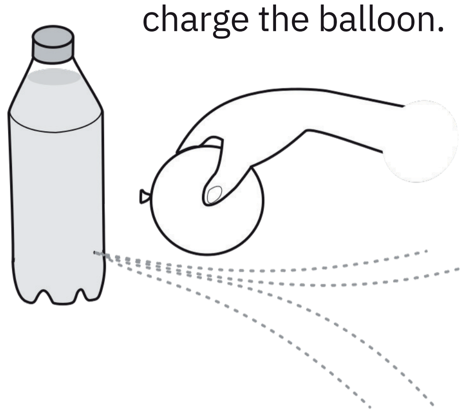
❸ On removing the lid, a thin stream of water will flow out from the hole.



❹ Rub an inflated balloon with wool.

❺ This will electrically charge the balloon.

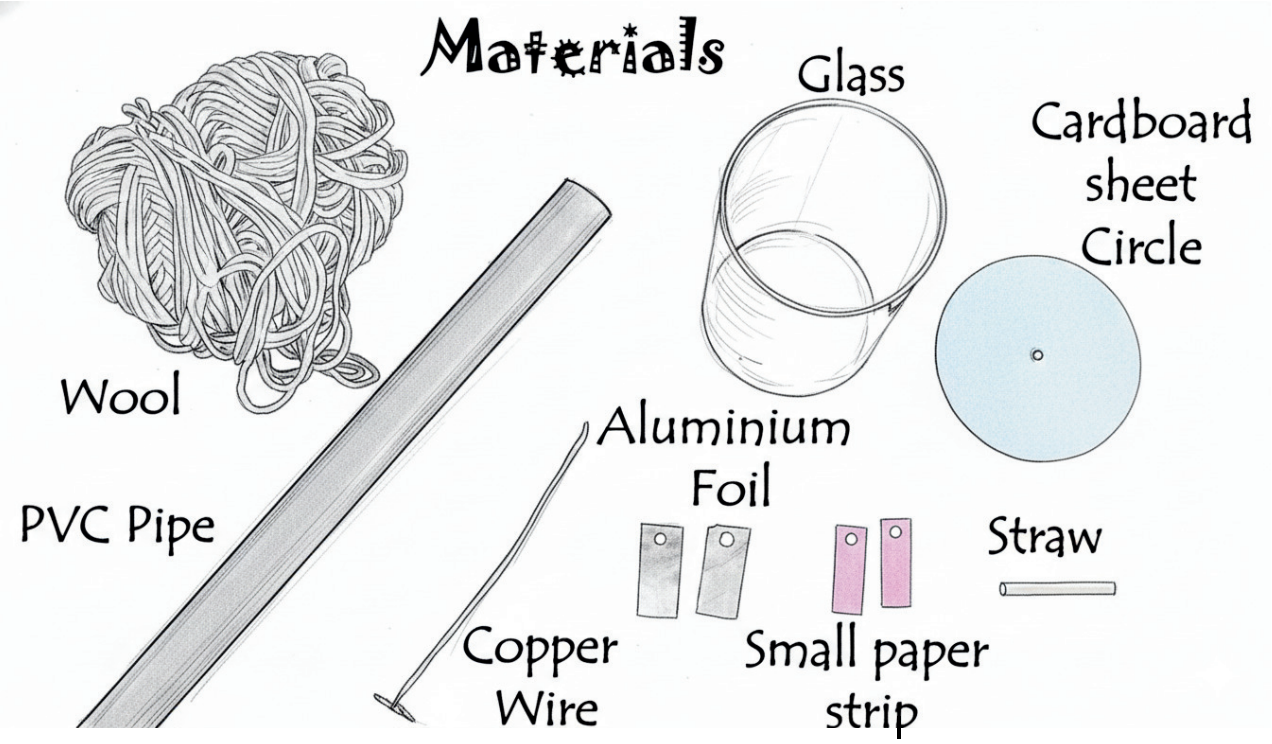


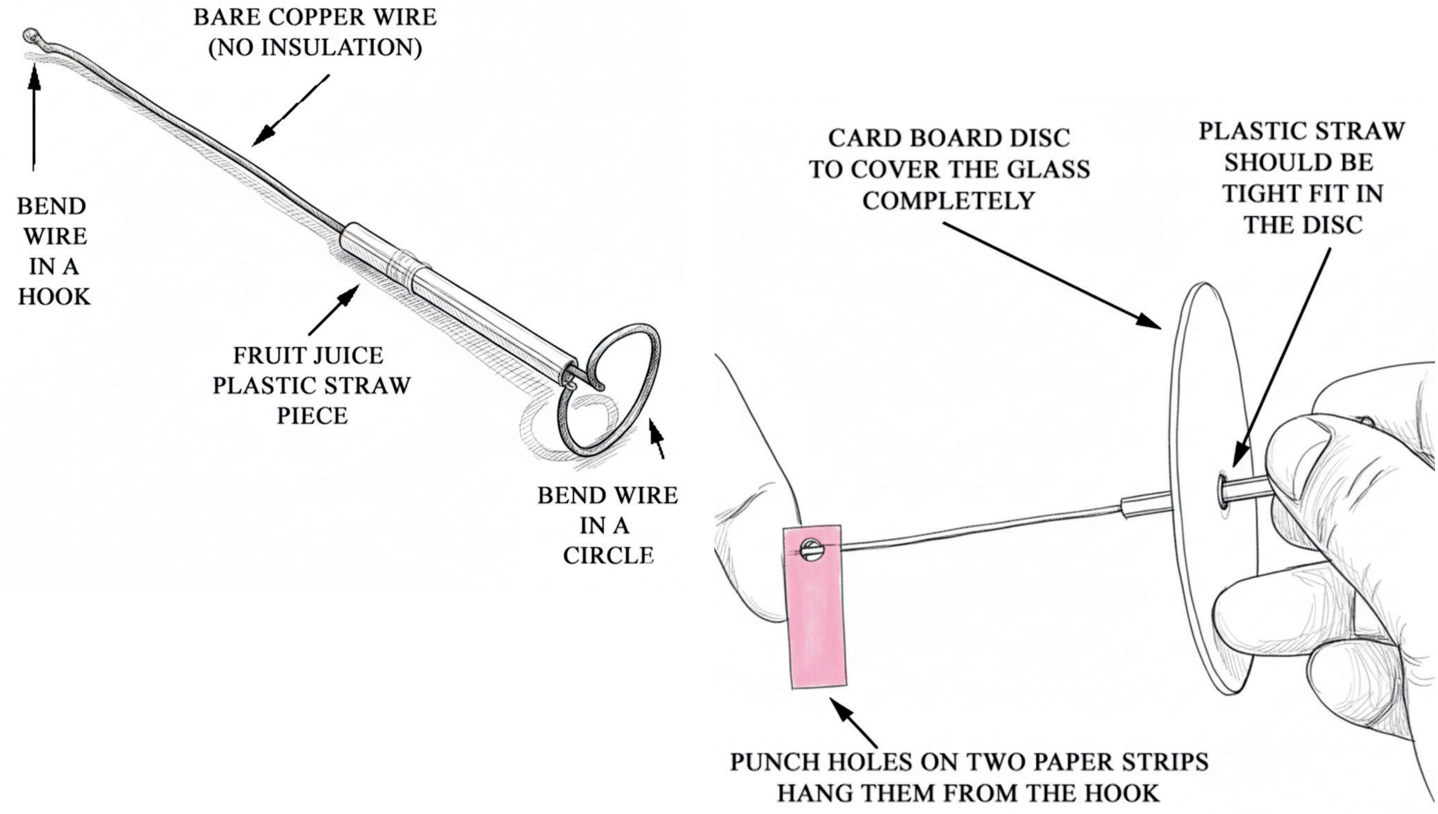


On rubbing the balloon with wool, some of its electrons get knocked off giving the balloon an electric charge. The thin stream of water is attracted to the charged balloon.

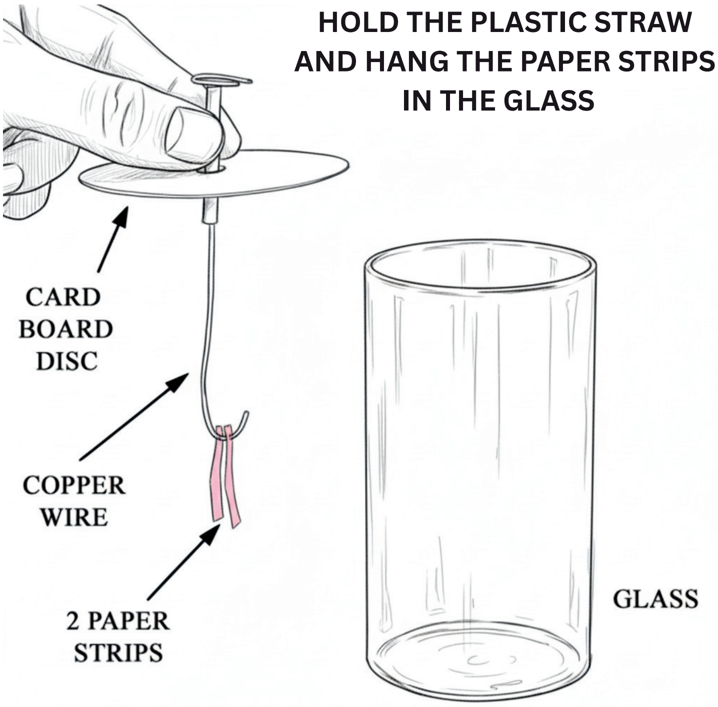
Then bring the balloon close to the water stream. The stream will be attracted to the charged balloon. Repeat the experiment using a comb, plastic scale and a straw.

4. SIMPLE PAPER ELECTROSCOPE

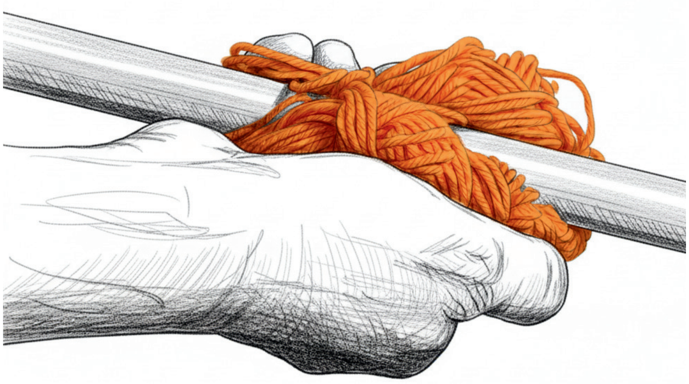

Materials
Glass
Cardboard sheet Circle
Wool
Aluminium Foil
PVC Pipe
Straw
Copper Wire
Small paper strip

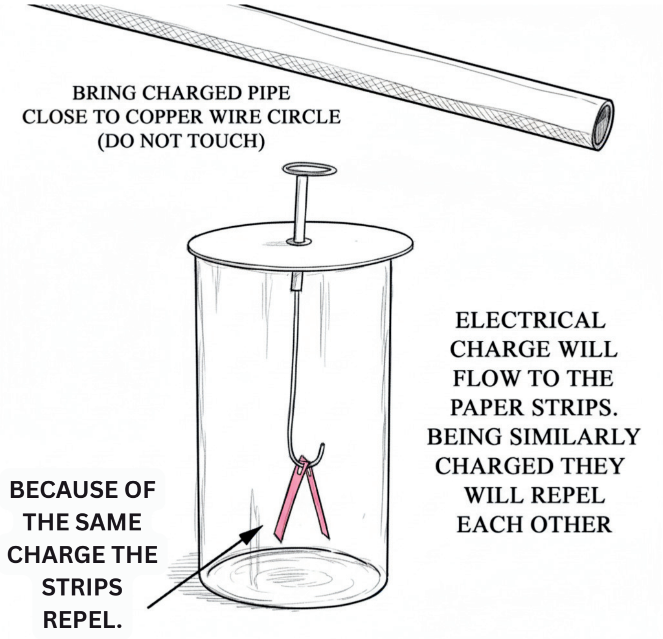

BARE COPPER WIRE (NO INSULATION)
BEND WIRE IN A HOOK
FRUIT JUICE PLASTIC STRAW PIECE
BEND WIRE IN A CIRCLE
CARD BOARD DISC TO COVER THE GLASS COMPLETELY
PLASTIC STRAW SHOULD BE TIGHT FIT IN THE DISC
PUNCH HOLES ON TWO PAPER STRIPS HANG THEM FROM THE HOOK

HOLD THE PLASTIC STRAW AND HANG THE PAPER STRIPS IN THE GLASS


CARD BOARD DISC
COPPER WIRE
2 PAPER STRIPS
GLASS

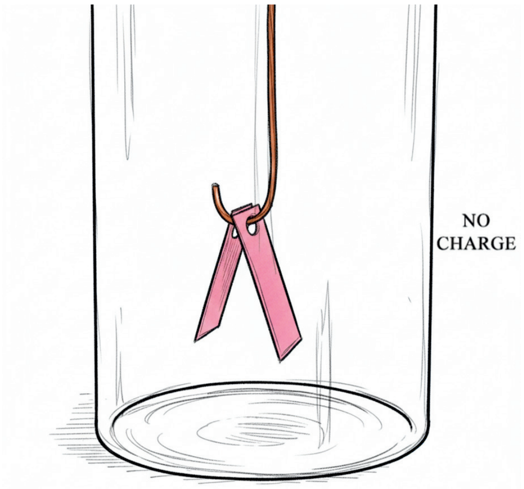
RUB A PIECE OF PVC PIPE WITH WOOL. THIS WILL ELECTRICALLY CHARGE THE PIPE



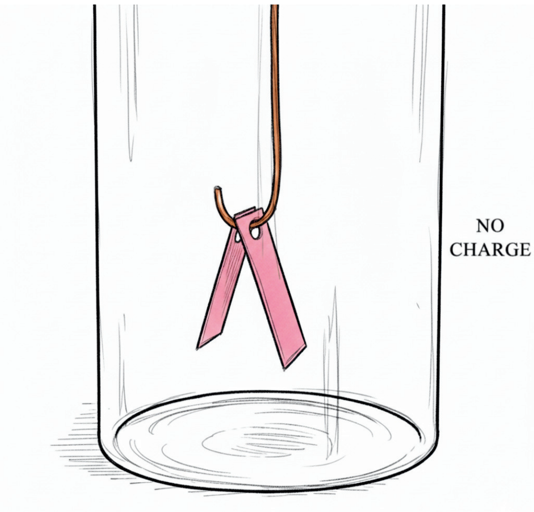

BRING CHARGED PIPE
CLOSE TO COPPER WIRE CIRCLE
(DO NOT TOUCH)

ELECTRICAL CHARGE WILL FLOW TO THE PAPER STRIPS. BEING SIMILARLY CHARGED THEY WILL REPEL EACH OTHER

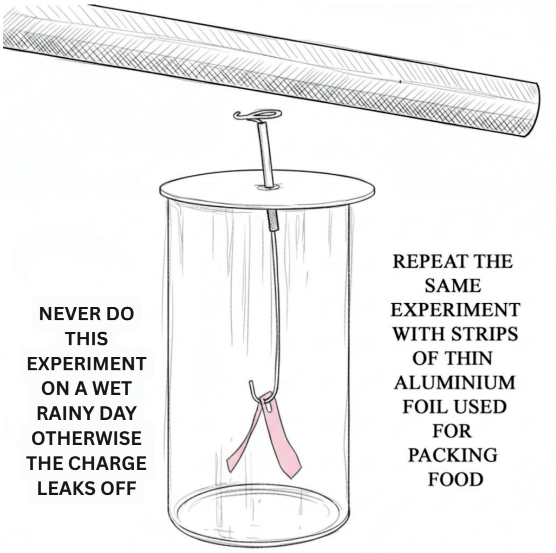
BECAUSE OF THE SAME CHARGE THE STRIPS REPEL.



NO CHARGE STRIPS ARE CLOSE TO EACH OTHER



WITH SAME CHARGE THE STRIPS REPEL EACH OTHER

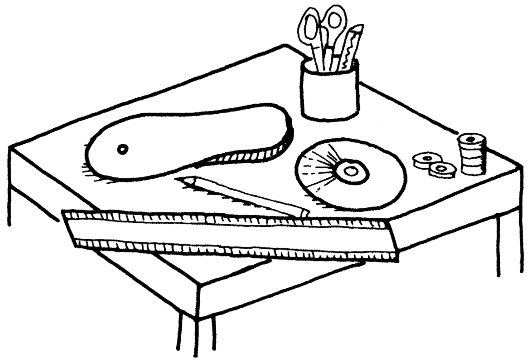


NEVER DO THIS EXPERIMENT ON A WET RAINY DAY OTHERWISE THE CHARGE LEAKS OFF

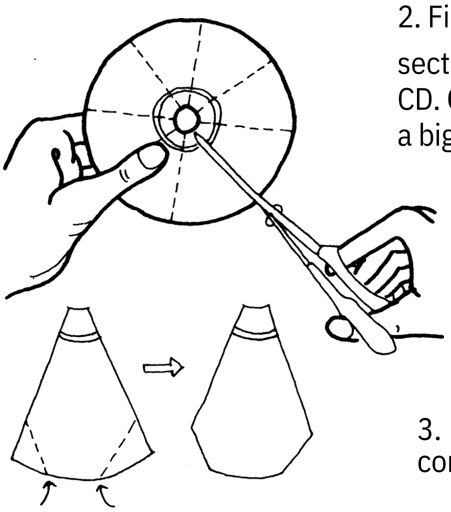
REPEAT THE SAME EXPERIMENT WITH STRIPS OF THIN ALUMINIUM FOIL USED FOR PACKING FOOD

5. MAGNETIC LEVITATION

This is simply a terrific toy. You can while away hours playing with it.
It also gives you a tremendous feel of what magnetic levitation is all about. It costs less than ten rupees.

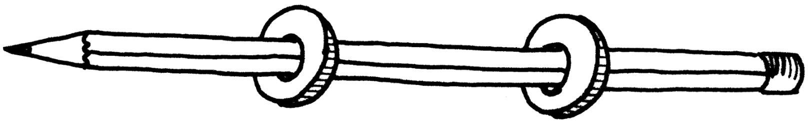


1. You need an old rubber slipper, discarded CD, 6 ring magnets (17.5-mm outer dia, 7.5-mm inner dia, 3-mm thick - they cost 1 rupee each), one pencil and few simple hand tools.

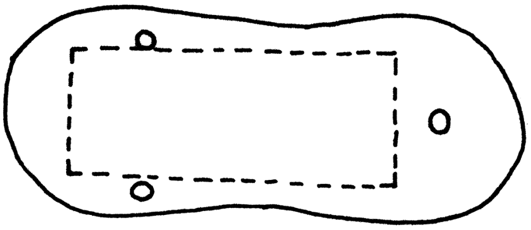


2. First mark out 8 equal sectors in the discarded CD. Cut one sector using a big scissors.

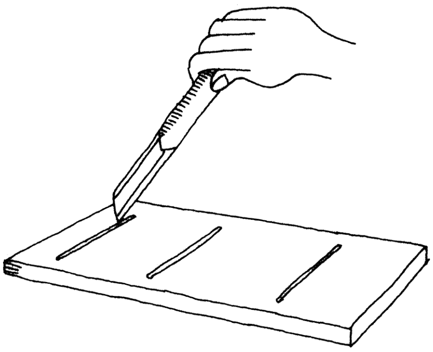
3. Cut the lower corners at an angle.



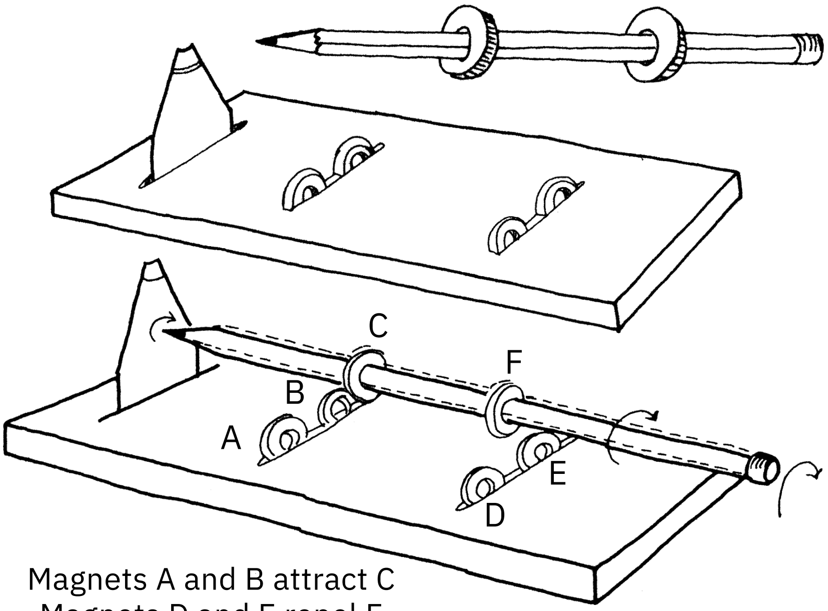
4. Take two ring magnets and press fit them in a pencil. They are just right to fit into a pencil. You might have to scrape the pencil a bit. The polarities of the magnets do not matter.



5. Cut a rectangle 15-cm x 7.5-cm from an old rubber slipper.



6. From one end mark out lines at 2-cm, 6.5-cm and 12.5-cm. Make 5-cm wide cuts on these lines.

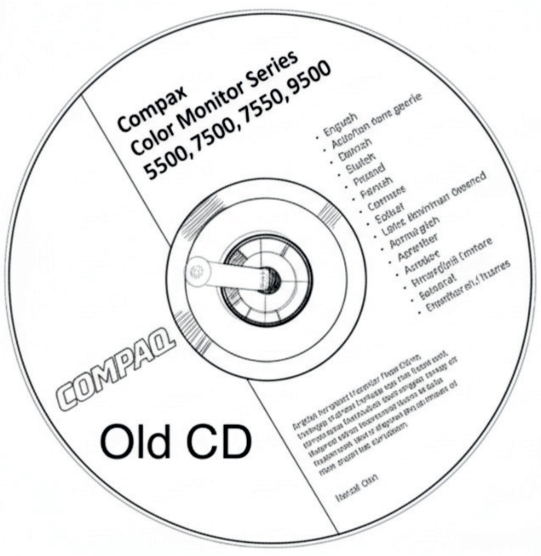


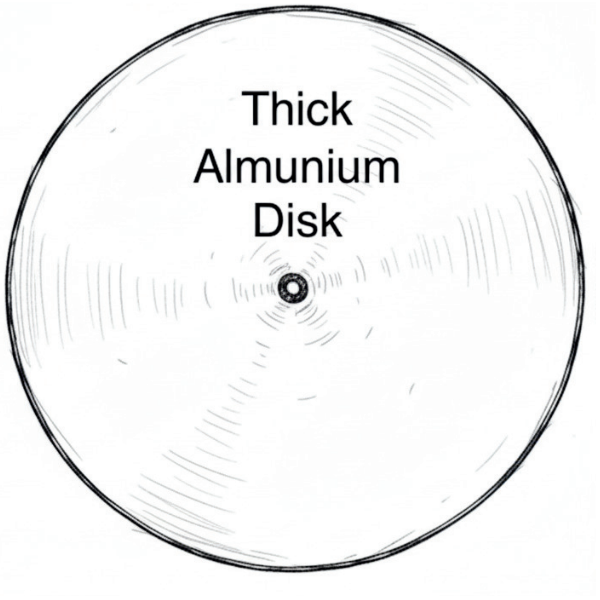
7. Now insert the CD piece. Place 2 ring magnets in the rubber slit next to the CD. These magnets must have poles which attract the pencil magnet close to the writing end. Insert two more ring magnets in the other slits. These magnets must repel the pencil magnet (away from the writing end)

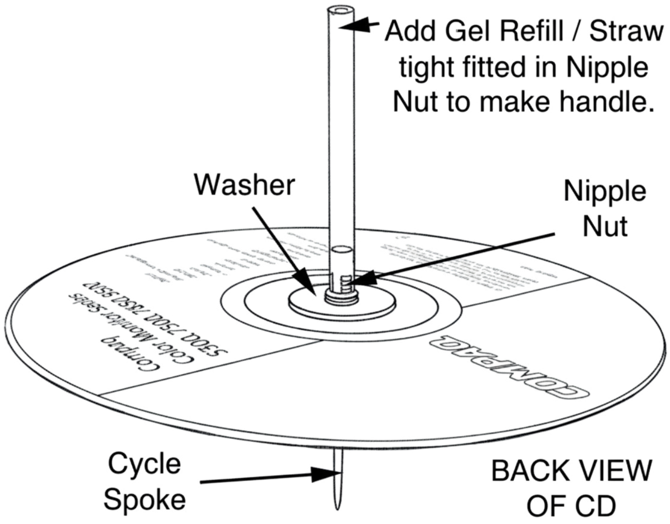
8. If you now place the pencil it will levitate in air with its tip resting on the CD. Now twirl the rear end of the pencil and it will keep spinning for a long time.
You may have to adjust the positions of the pencil magnets a bit to get the pencil to levitate.

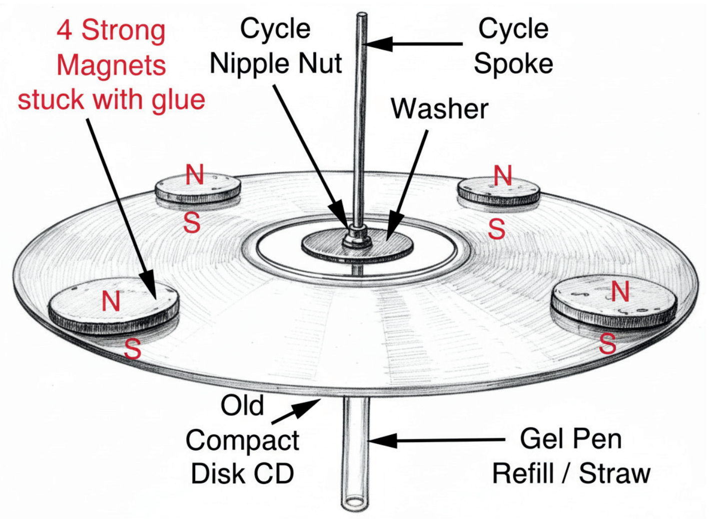
Magnets A and B attract C
Magnets D and E repel F

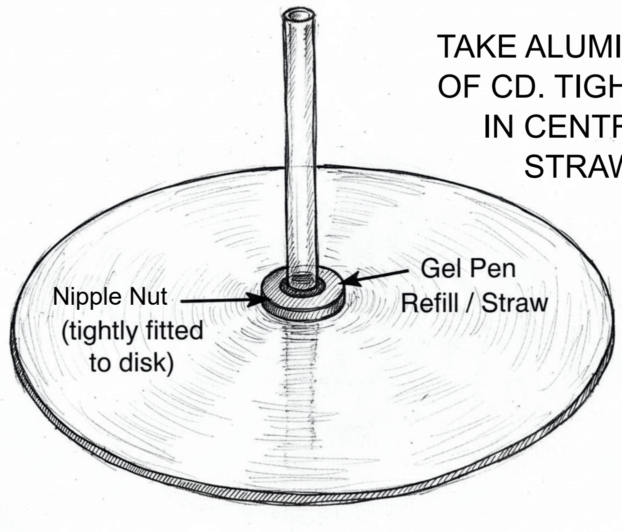
6. MAGNETIC BRAKE


Compax
Color Monitor Series
5500,7500,7550,9500
COMPAQ
Old CD


Thick
Almunium
Disk

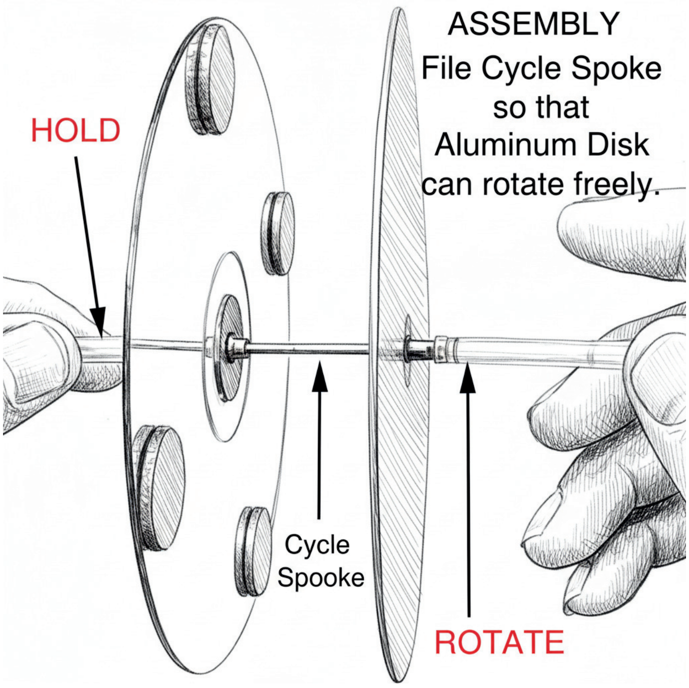

Add Gel Refill / Straw tight fitted in Nipple Nut to make handle.
Washer
Nipple Nut
Cycle Spoke
BACK VIEW OF CD


4 Strong Magnets stuck with glue
Cycle Nipple Nut
Cycle Spoke
Washer
N
S
N
S
N
S
N
S
Old Compact Disk CD
Gel Pen Refill / Straw

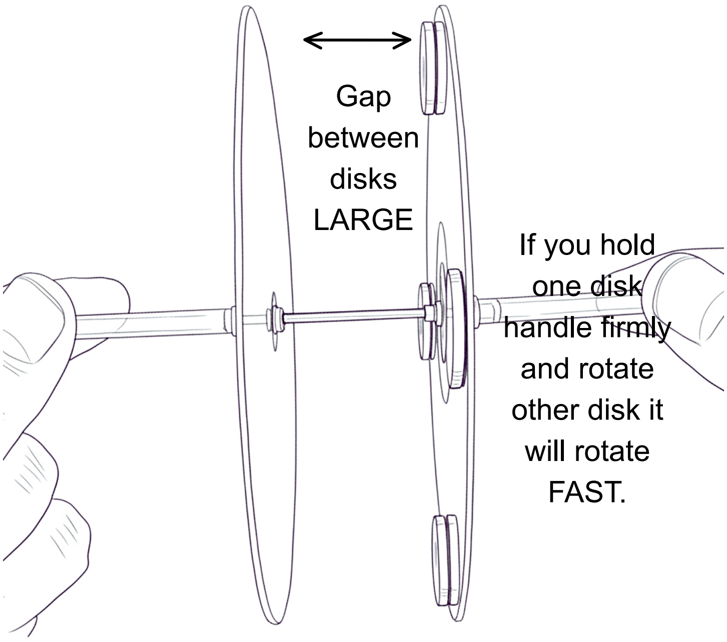

Nipple Nut (tightly fitted to disk)
Gel Pen Refill / Straw

TAKE ALUMINIUM DISK THE SIZE OF CD. TIGHTLY FIT NIPPLE NUT IN CENTRE. GLUE REFILL / STRAW FOR HANDLE

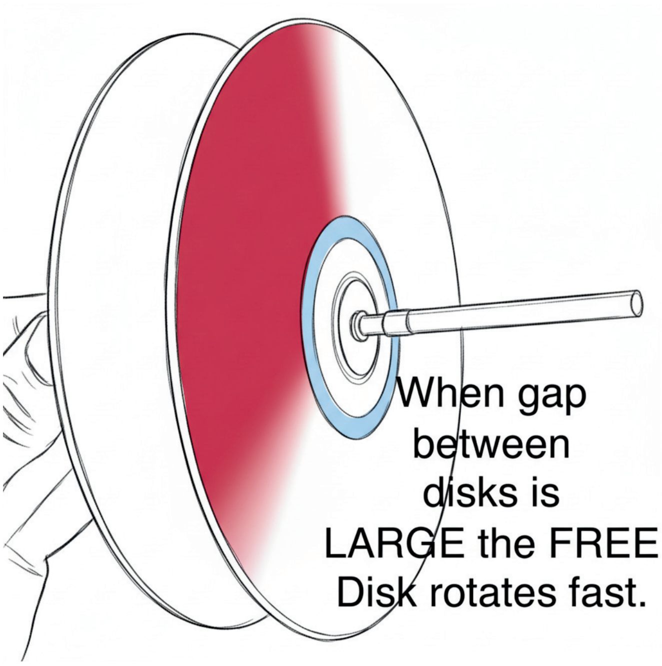
THICK ALUMINIUM DISK

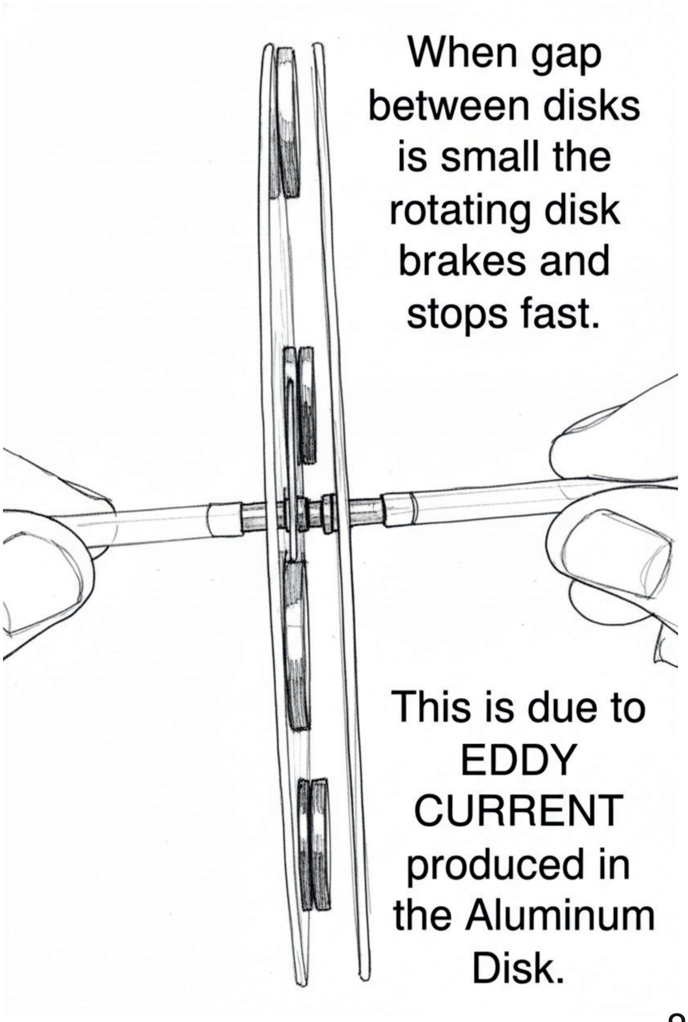


ASSEMBLY
File Cycle Spoke
so that
Aluminum Disk
can rotate freely.


Gap
between
disks
LARGE

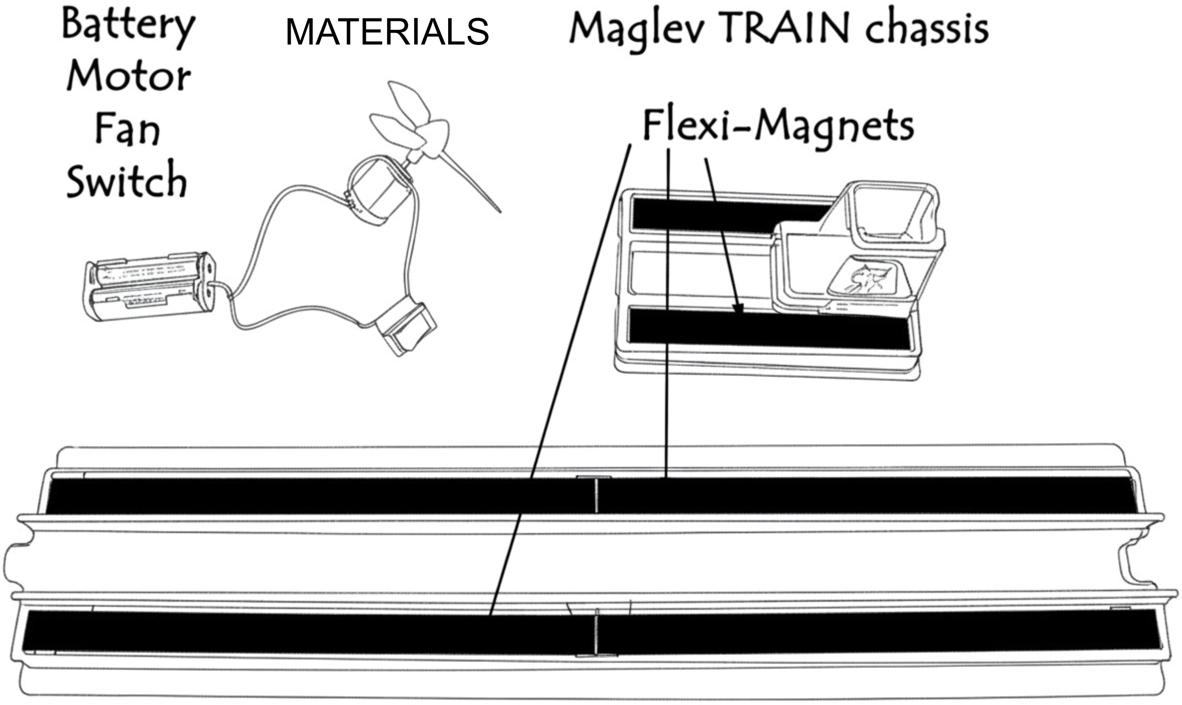
If you hold
one disk
handle firmly
and rotate
other disk it
will rotate
FAST.


When gap
between
disks is
LARGE the FREE
Disk rotates fast.

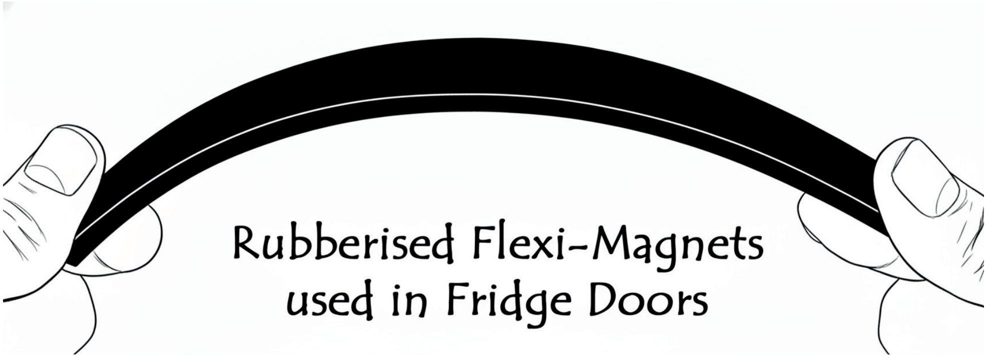

When gap
between disks
is small the
rotating disk
brakes and
stops fast.

This is due to
EDDY
CURRENT
produced in
the Aluminum
Disk.

7. MAGLEV TRAIN

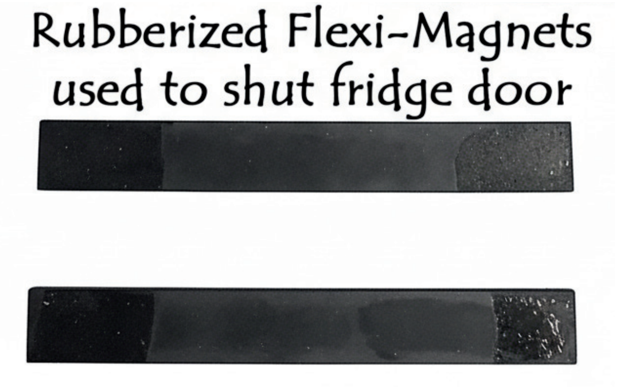

Battery
Motor
Fan
Switch
MATERIALS
Maglev TRAIN chassis
Flexi-Magnets

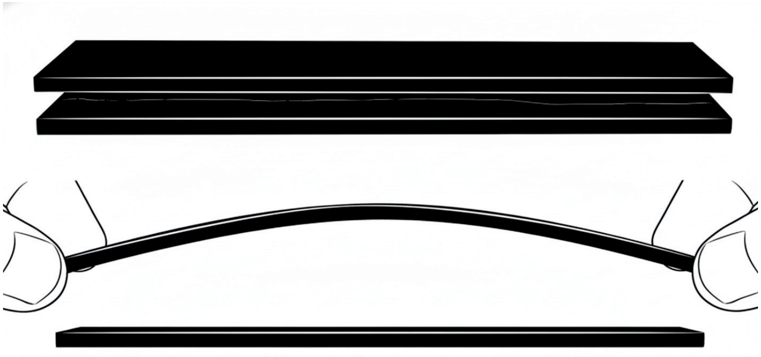
TRACK made with Rubberized Flexi-magnets
+ Plastic Rail

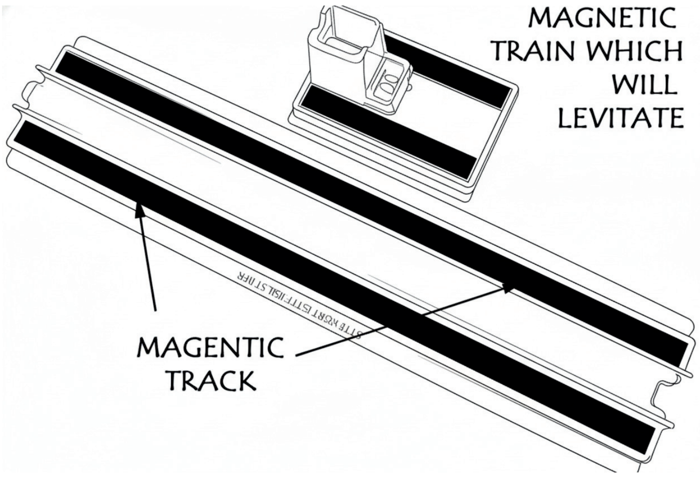


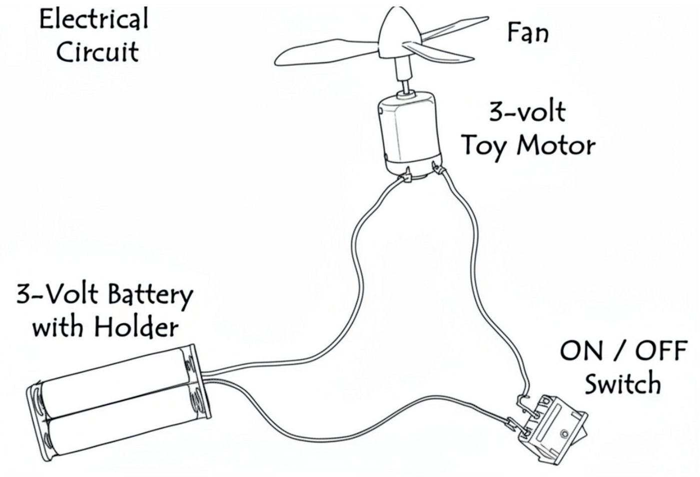
Rubberised Flexi-Magnets
used in Fridge Doors

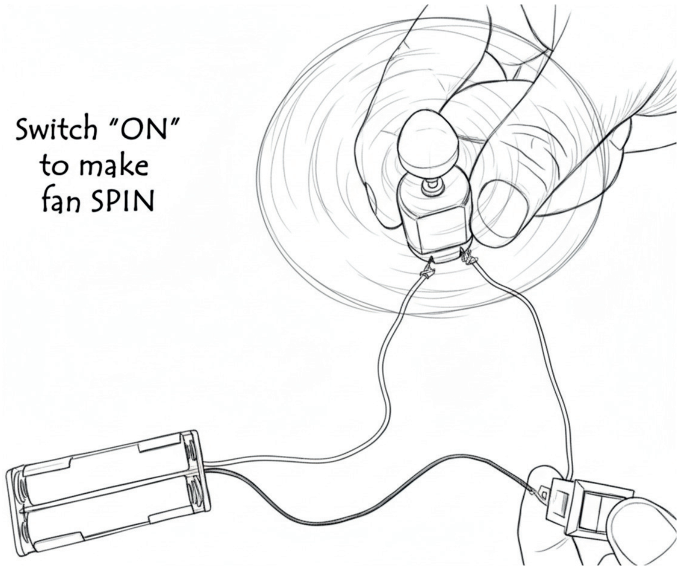
Rubberized Flexi-Magnets

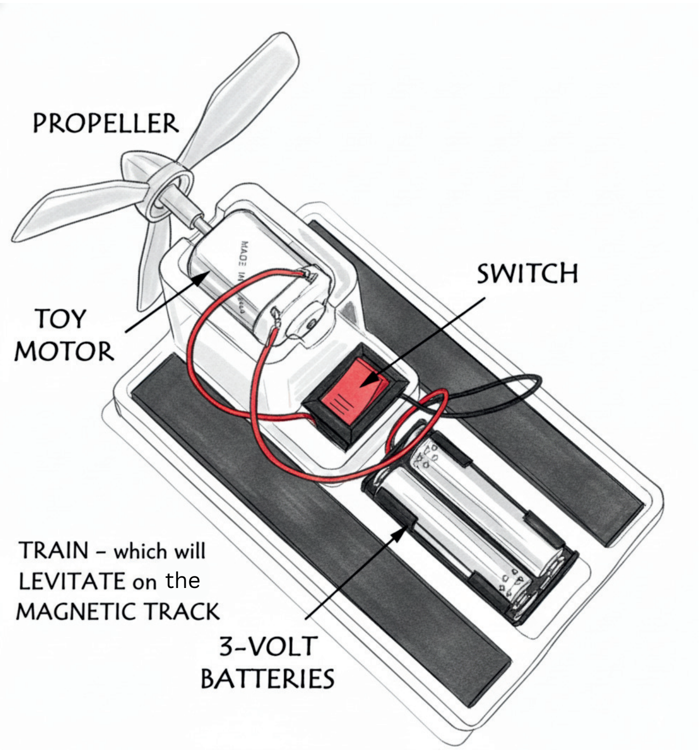

Rubberized Flexi-Magnets
used to shut fridge door

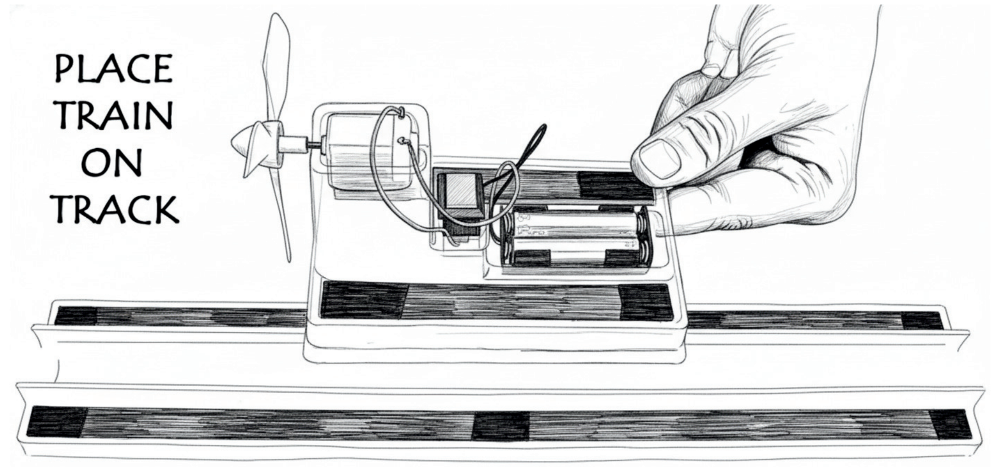

Similar Poles - REPEL


MAGNETIC TRAIN WHICH WILL LEVITATE
MAGENTIC TRACK

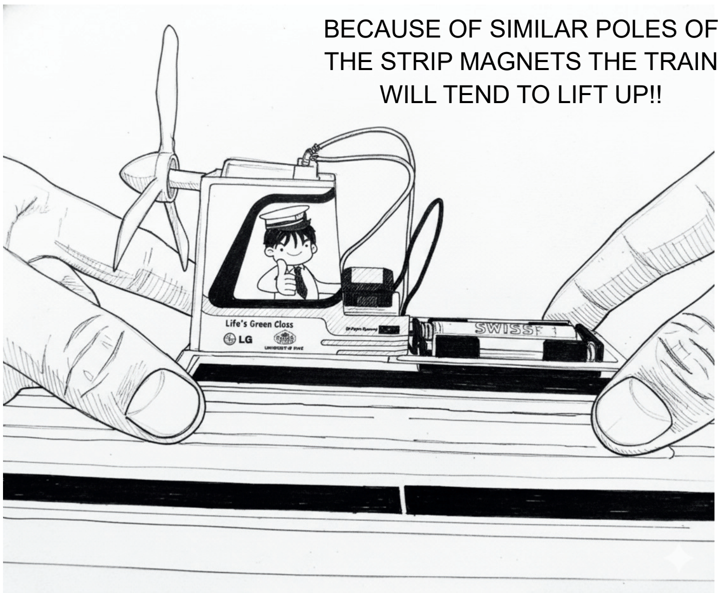

Electrical Circuit
Fan
3-volt Toy Motor
3-Volt Battery with Holder
ON / OFF Switch


Switch "ON" to make fan SPIN

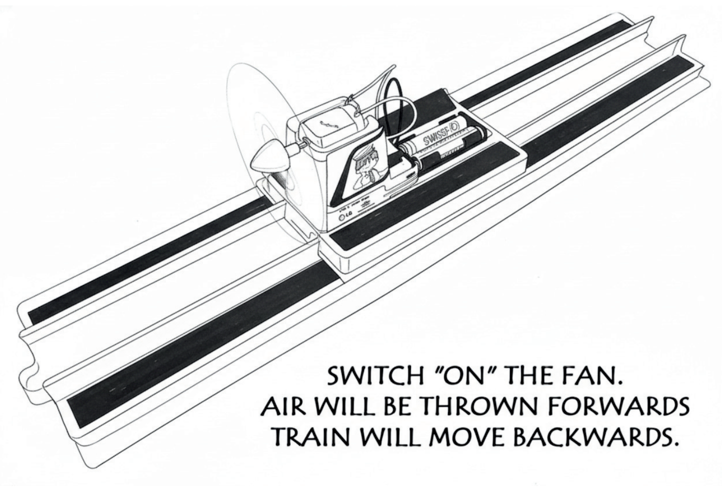

PROPELLER
TOY MOTOR
SWITCH
TRAIN - which will LEVITATE on the MAGNETIC TRACK
3-VOLT BATTERIES

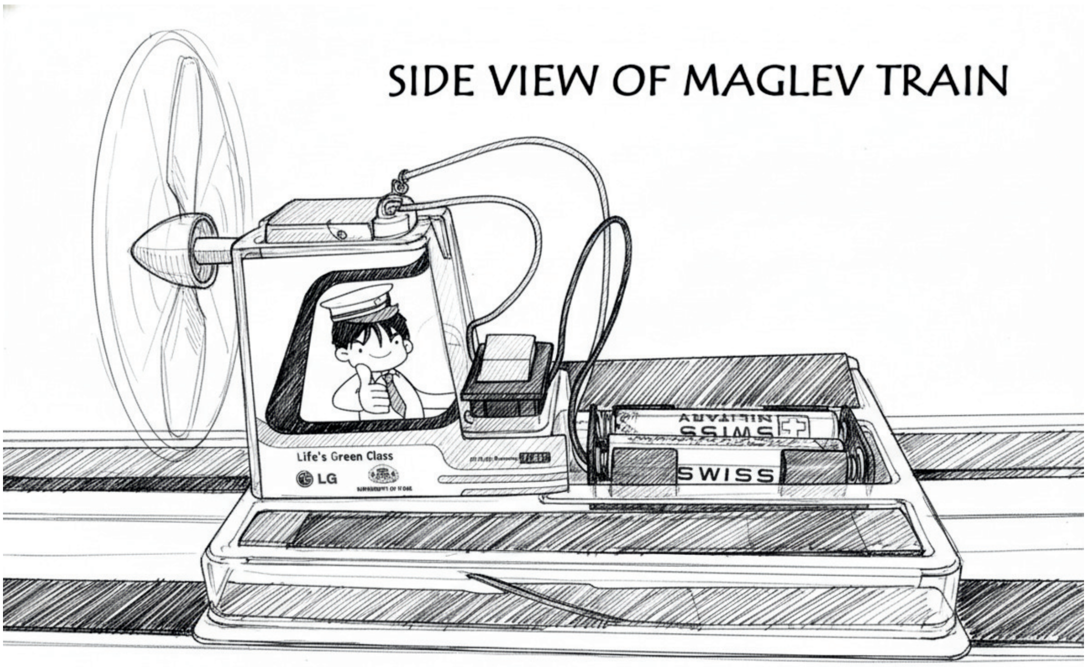

PLACE
TRAIN
ON
TRACK

BECAUSE OF SIMILAR POLES TRAIN WILL LIFT SLIGHTLY


BECAUSE OF SIMILAR POLES OF
THE STRIP MAGNETS THE TRAIN
WILL TEND TO LIFT UP!!

Life's Green Class
LG
SWISS

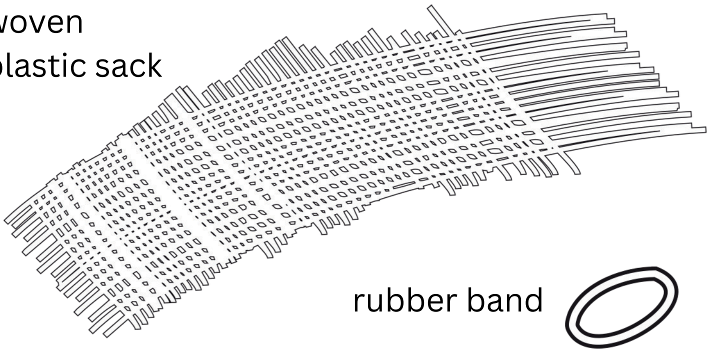

SWITCH "ON" THE FAN.
AIR WILL BE THROWN FORWARDS
TRAIN WILL MOVE BACKWARDS.


SIDE VIEW OF MAGLEV TRAIN

Life's Green Class
LG
SWISS

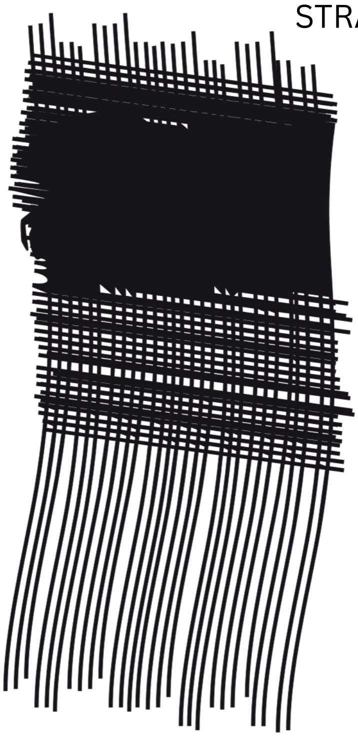
8. STATIC STRANDS

strip from a
woven
plastic sack



rubber band

STATIC
STRANDS

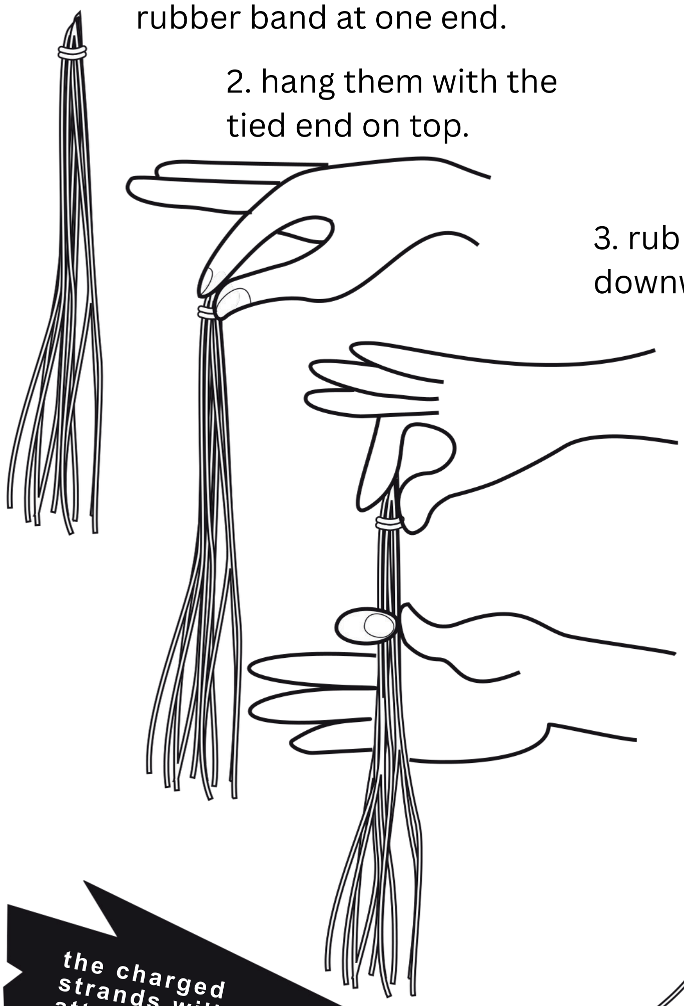


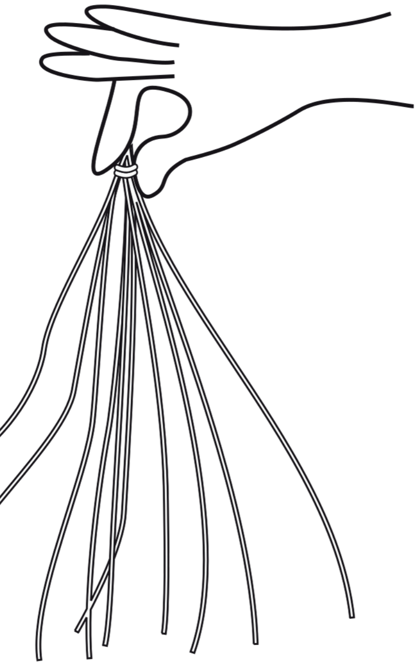
1. Join Ten, 45-cm long plastic strands with a rubber band at one end.

2. hang them with the tied end on top.

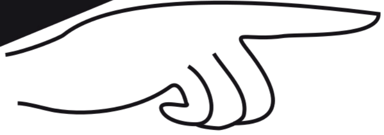
3. rub the strands downwards quickly.

4. The strands will acquire the same electrical charge and will repel each other.



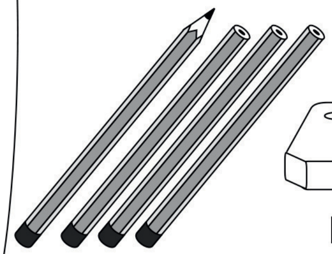


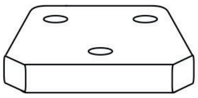
the charged strands willbe attracted to your finger!

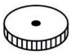


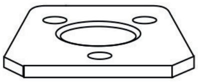
9. PEN PROP

YOU NEED


4 pencils

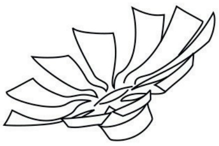

Rubber Base


Coin with dent

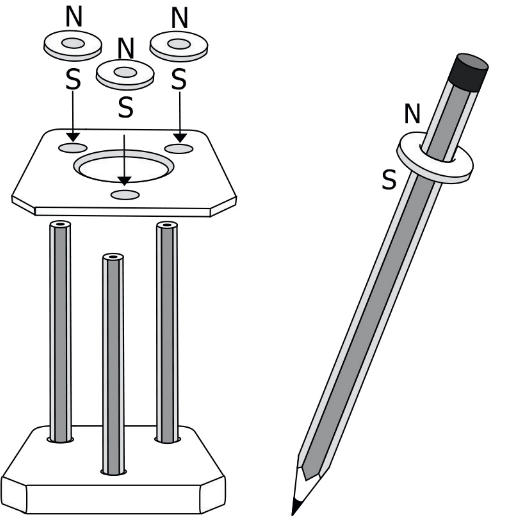

Thick card

Ring magnets

Glue

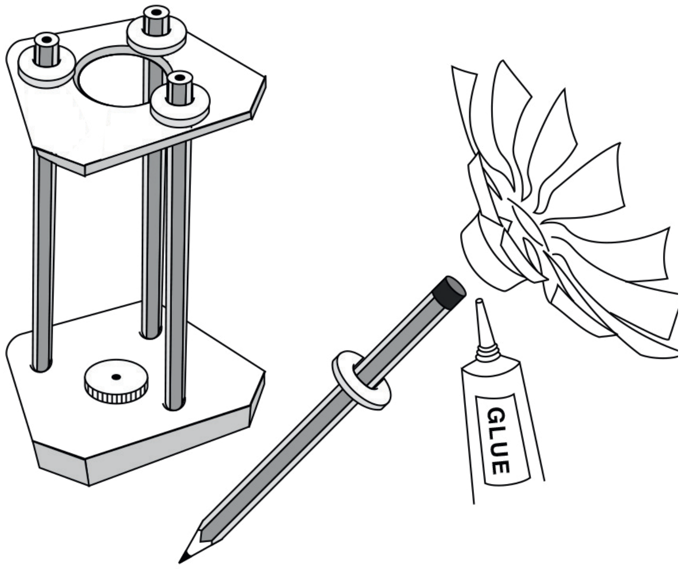

Bottle top fan

1



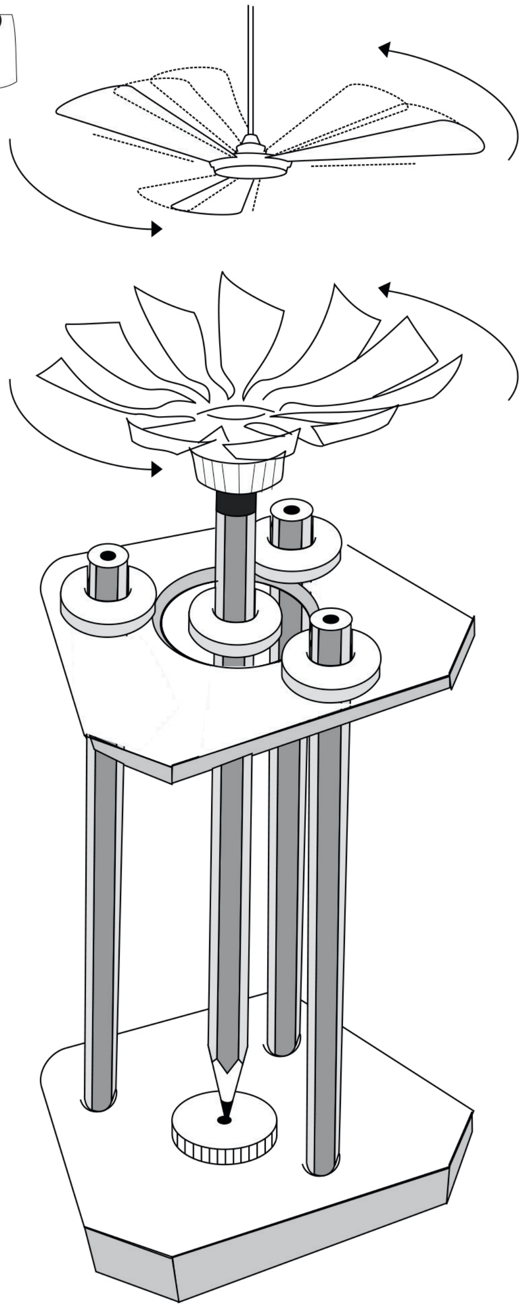
Stand 3 pencils on a rubber base. Stick thick card on top for support. Fix three ring magnets with same poles UP. Fix another magnet in a sharp pencil.

2



Stick a coin with a dent on the rubber. Make a fan from a bottle top and glue it to the middle pencil.

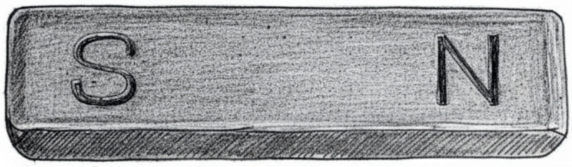
3



Adjust the central magnet to make the pencil stand on its point. Place under a ceiling fan to spin the pencil continuously.

10. MAGNETIC NEEDLE

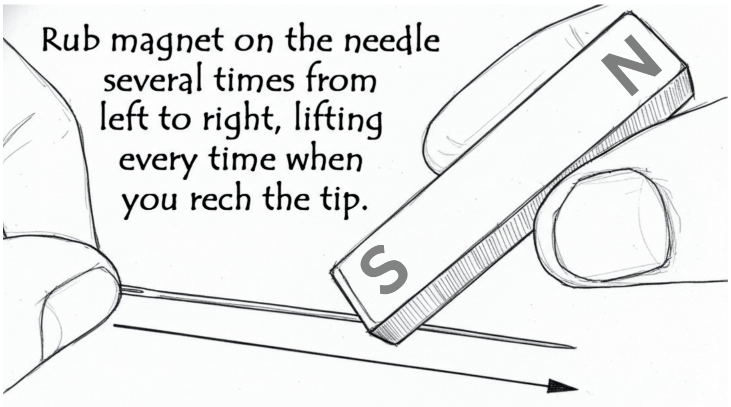
MATERIALS



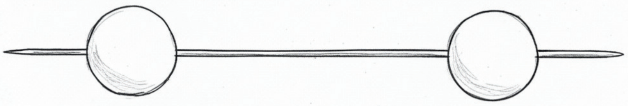
Magnet

Styrofoam balls

long Needle

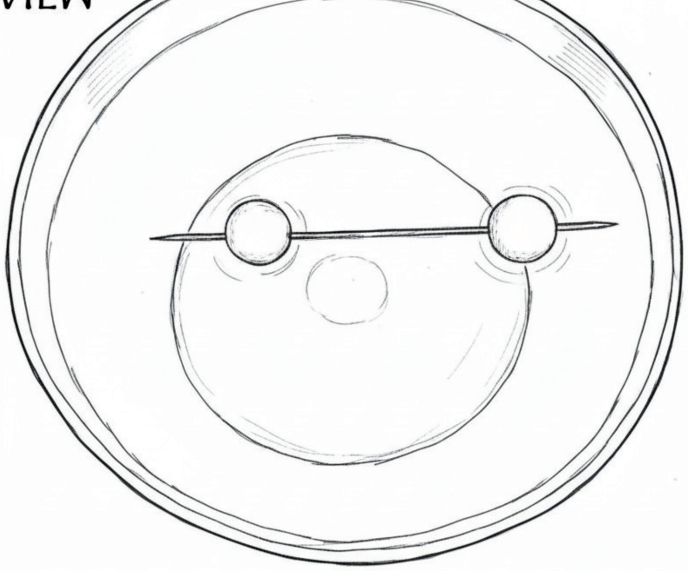


Rub magnet on the needle several times from left to right, lifting every time when you rech the tip.

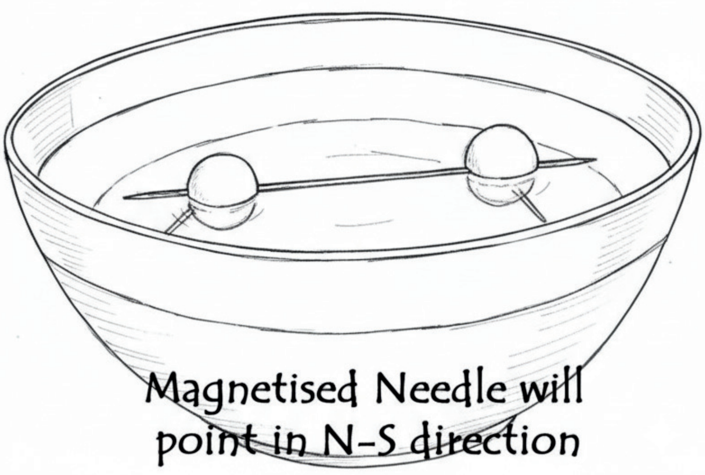


Insert Needle in styrofoam balls

TOP VIEW

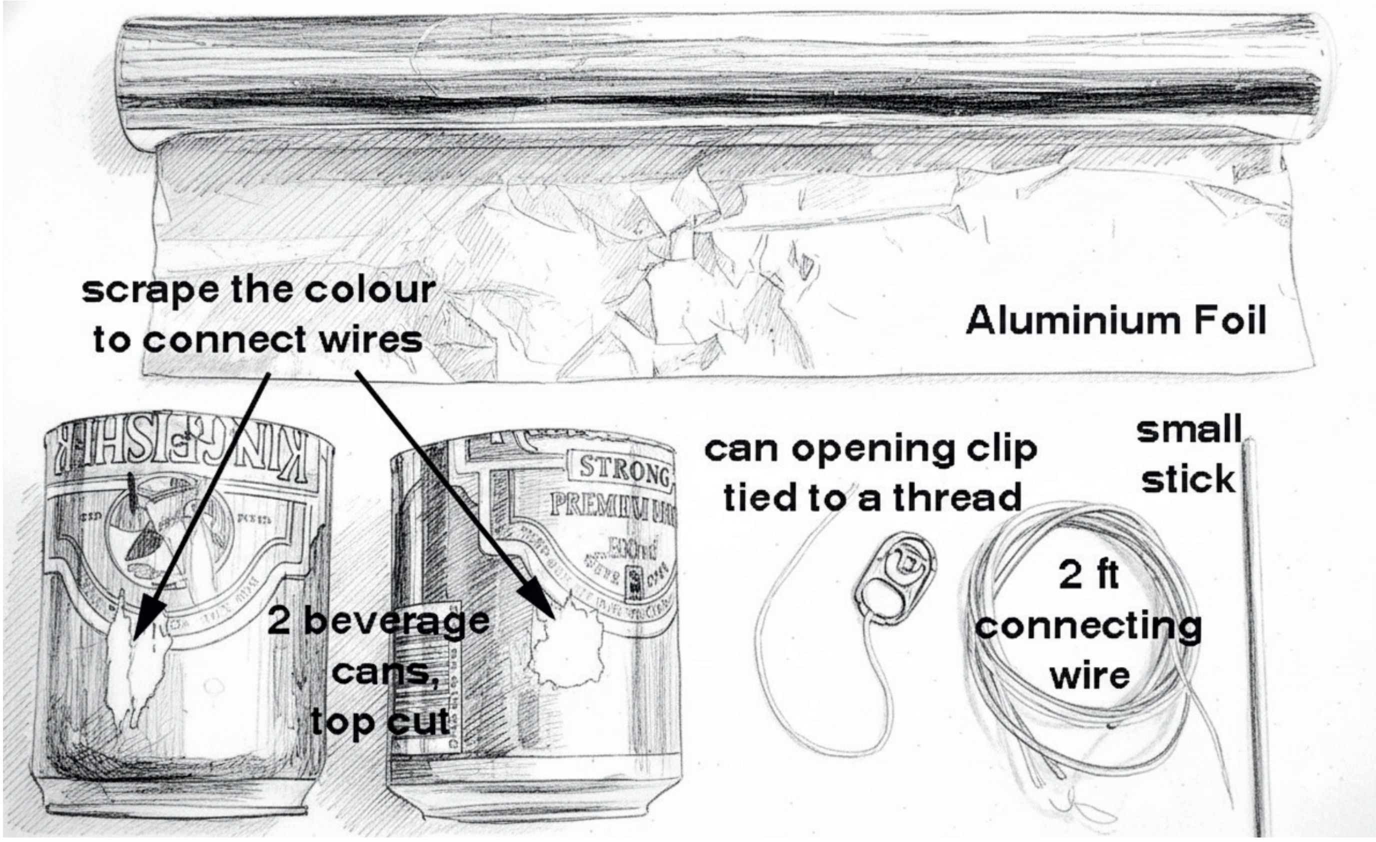


Side view

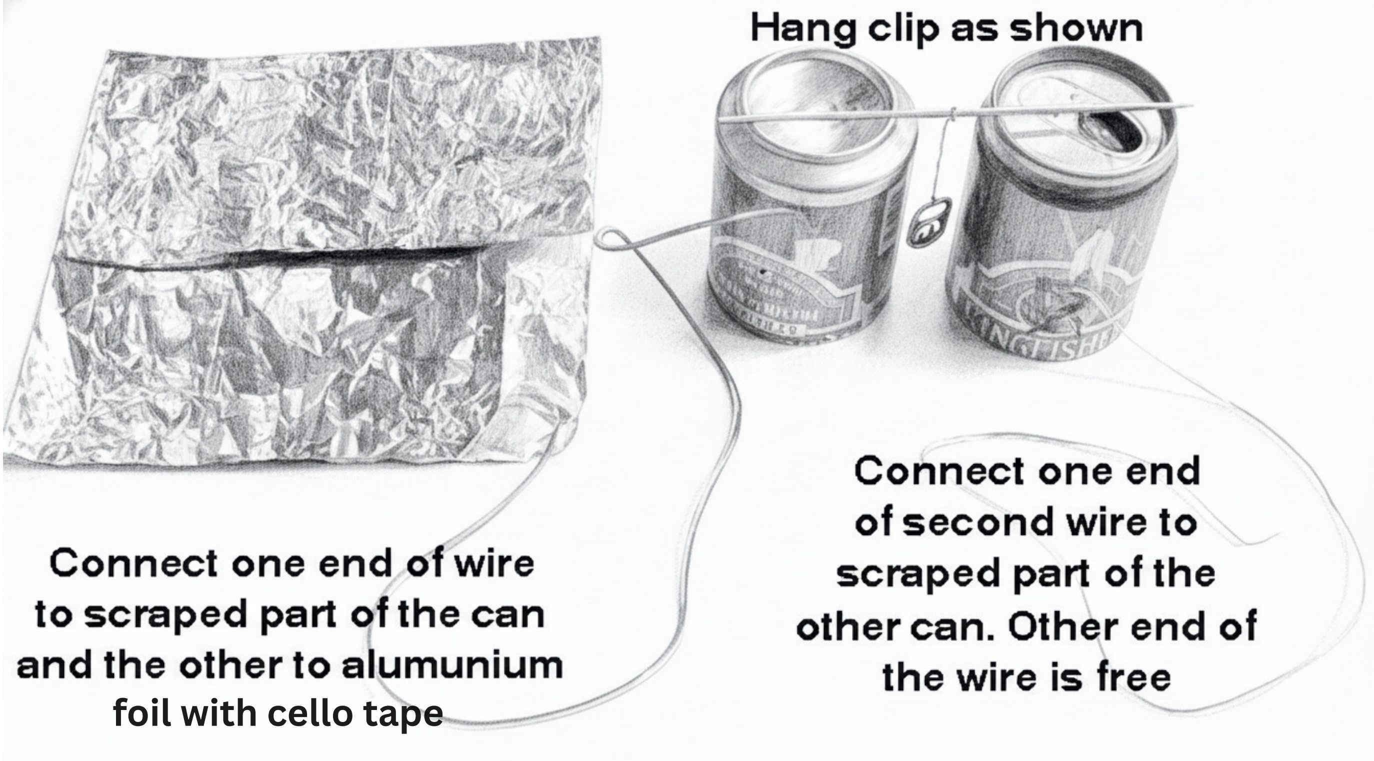


Magnetised Needle will point in N-S direction

11. STATIC BELL

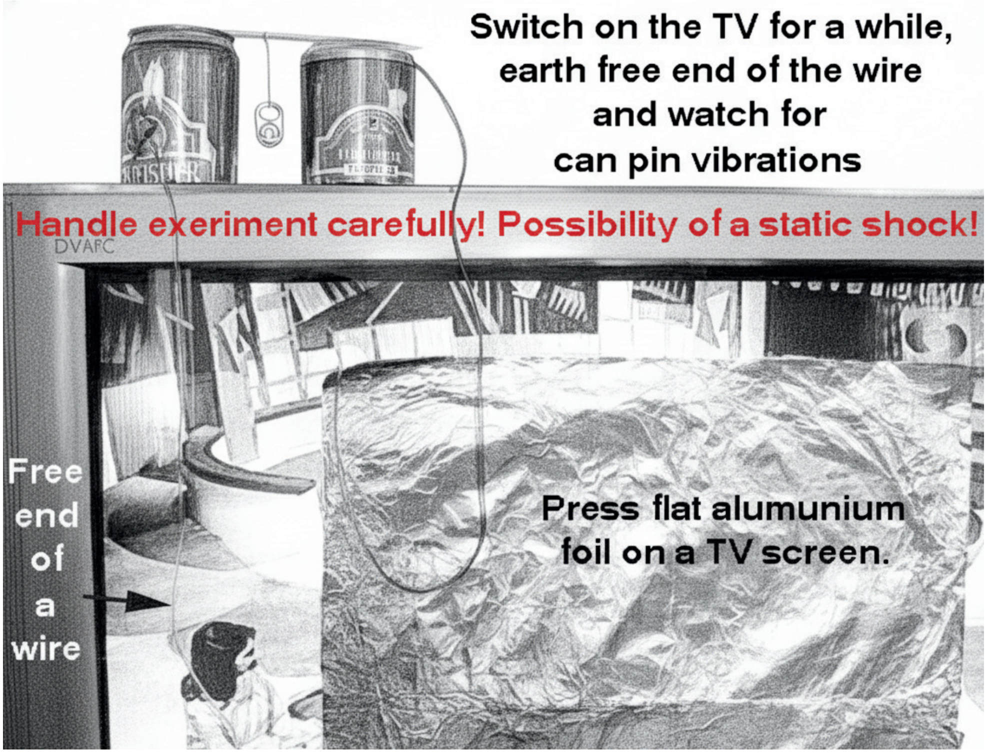

Aluminium Foil
can opening clip
tied to a thread
small
stick
2 ft
connecting
wire
2 beverage
cans,
top cut

scrape the colour to connect wires


Hang clip as shown

Connect one end of wire to scraped part of the can and the other to alumunium foil with cello tape

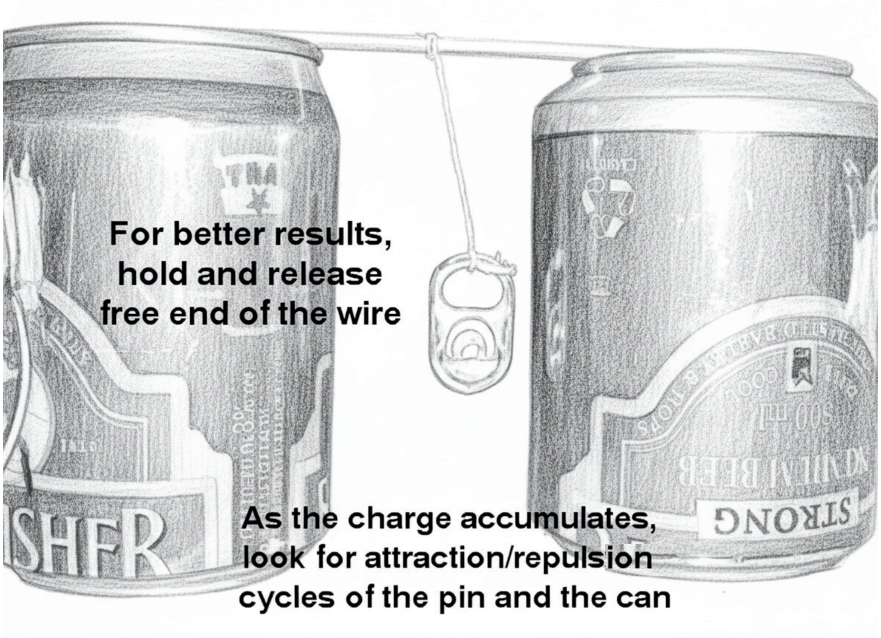
Connect one end of second wire to scraped part of the other can. Other end of the wire is free



Switch on the TV for a while, earth free end of the wire and watch for can pin vibrations

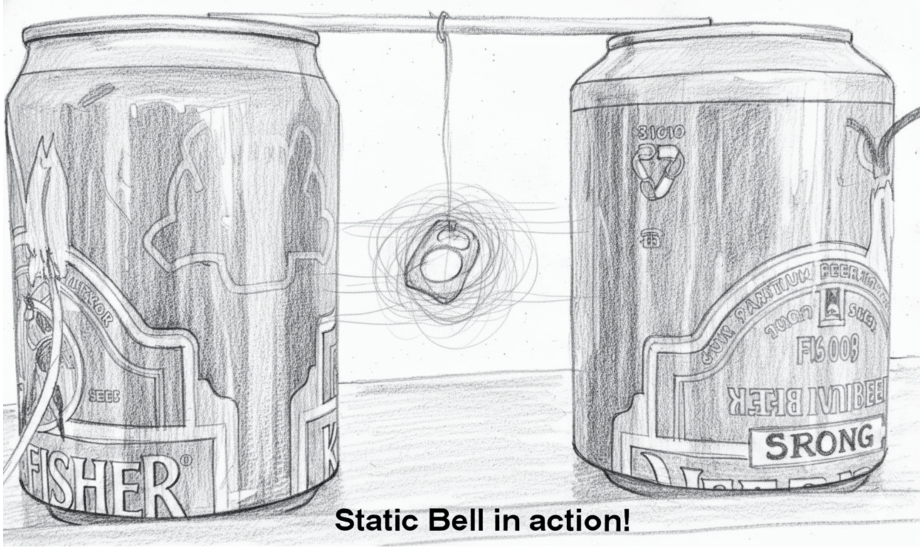
Handle exeriment carefully! Possibility of a static shock!

Press flat alumunium foil on a TV screen.



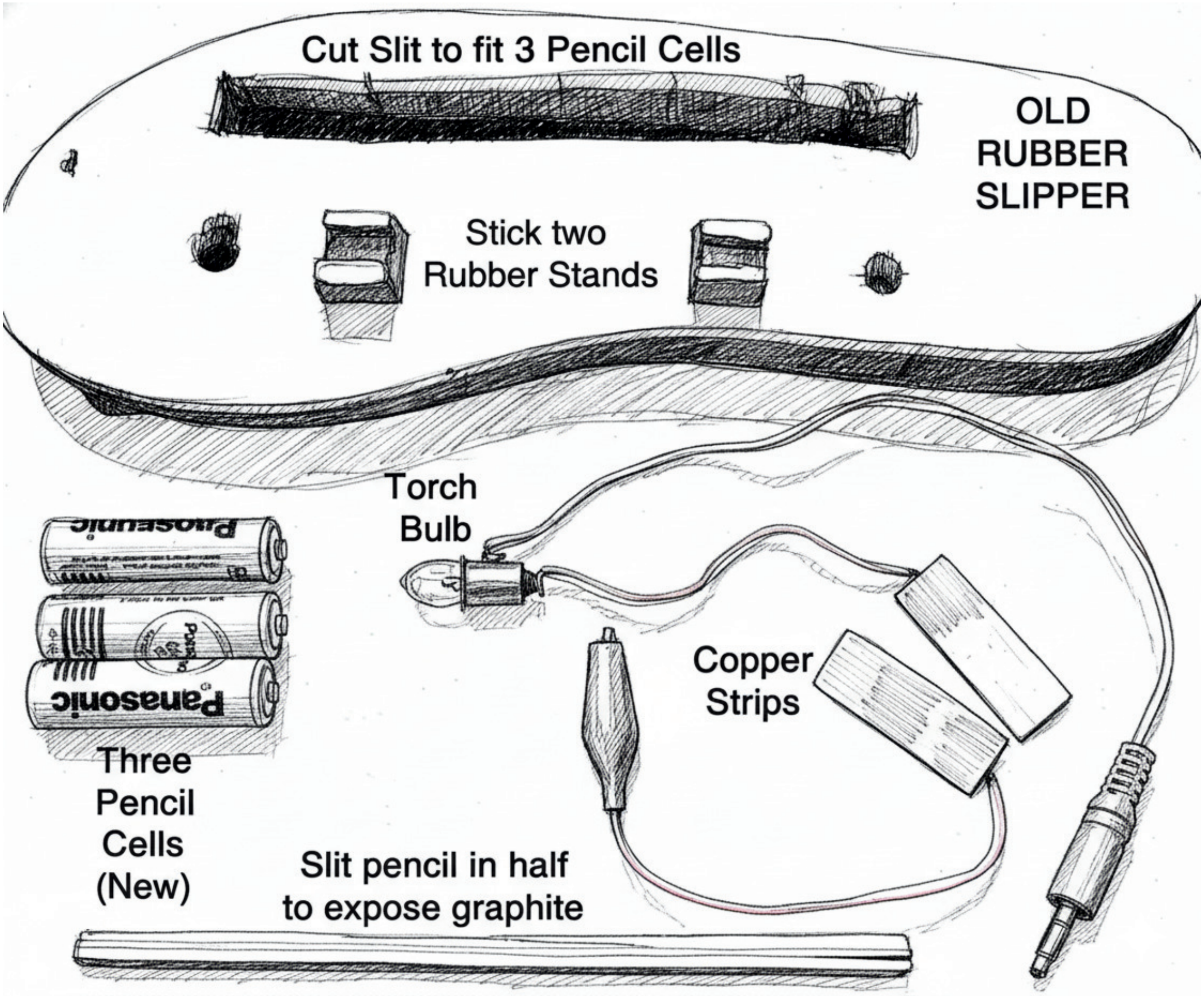
For better results, hold and release free end of the wire

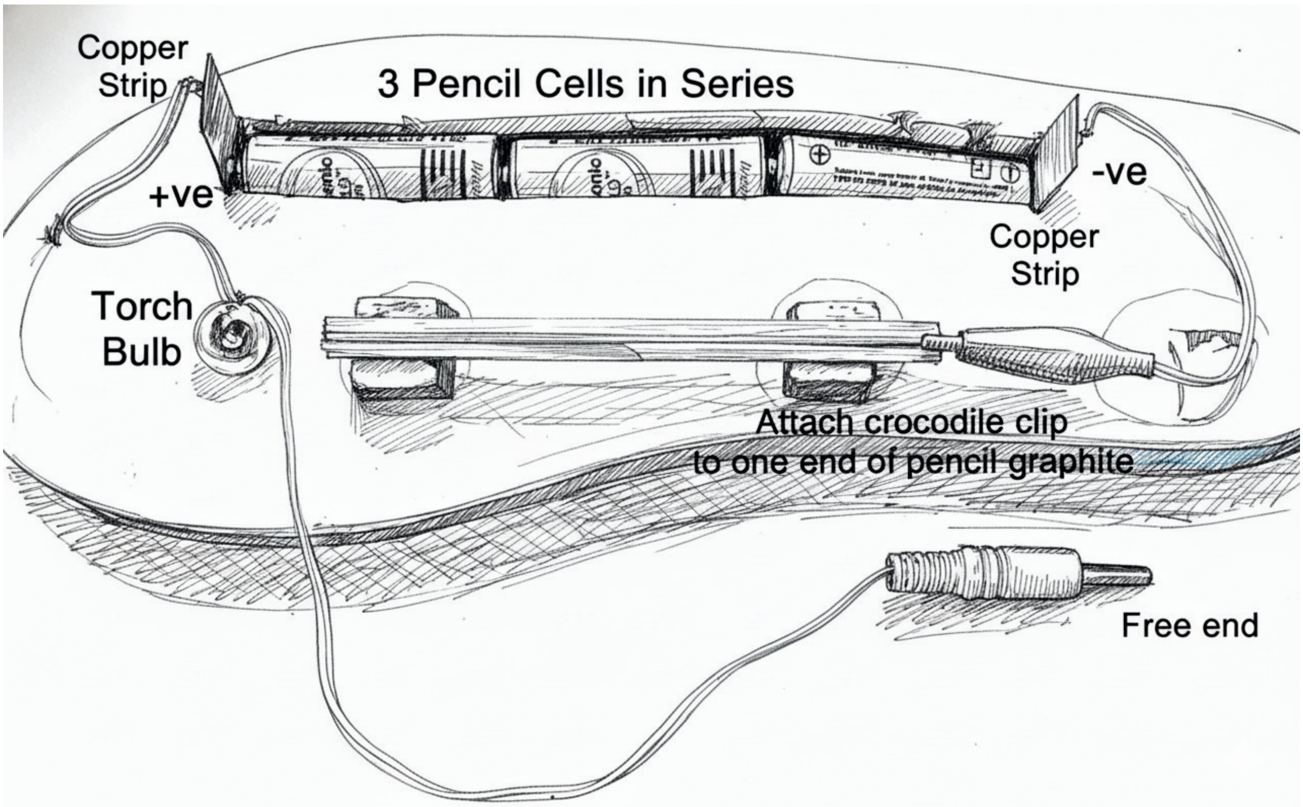
As the charge accumulates, look for attraction/repulsion cycles of the pin and the can

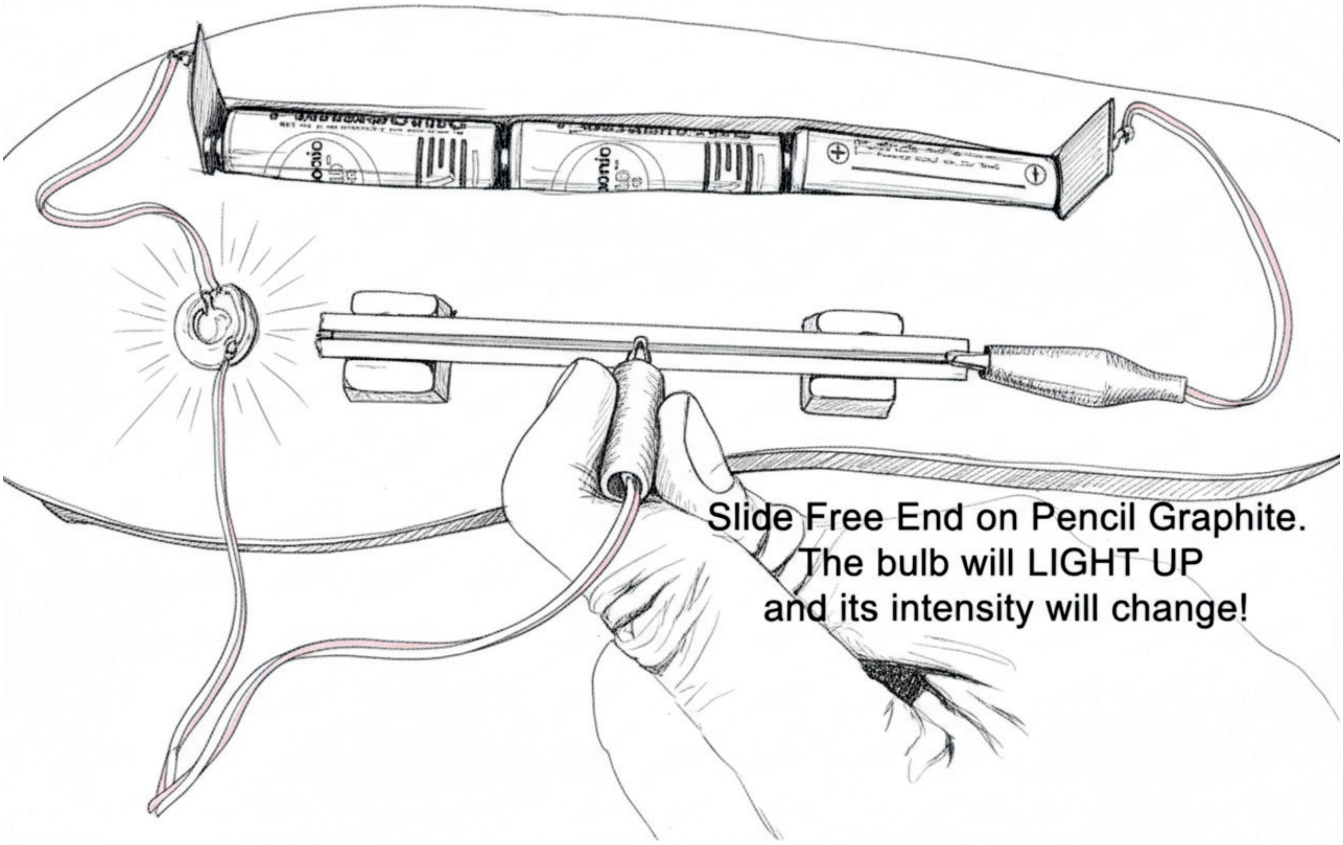


Static Bell in action!

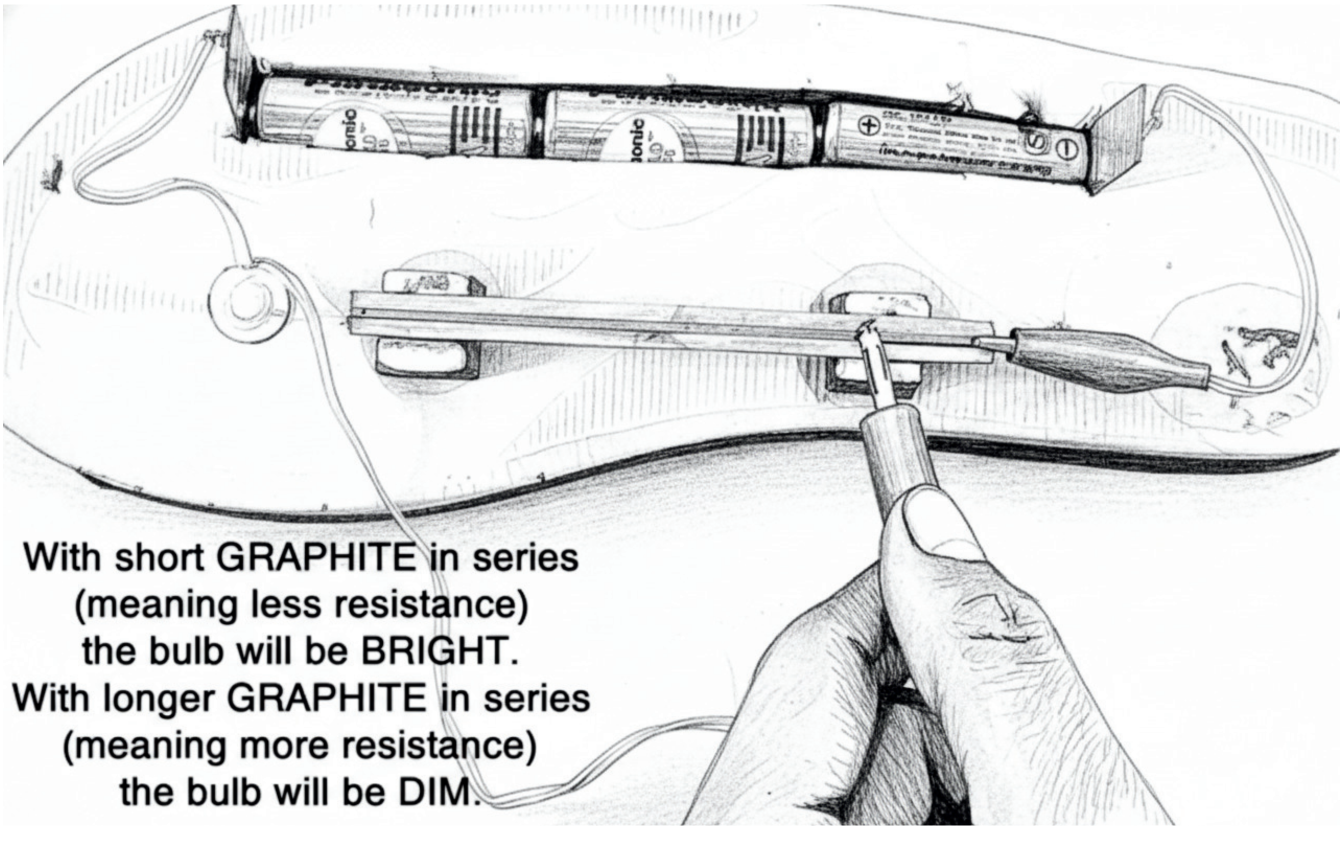
12. RESISTANT PENCIL


Cut Slit to fit 3 Pencil Cells
OLD RUBBER SLIPPER
Stick two Rubber Stands
Torch Bulb
Panasonic
Copper Strips
Three Pencil Cells (New)
Slit pencil in half to expose graphite


Copper Strip
3 Pencil Cells in Series
+ve
-ve
Copper Strip
Torch Bulb
Attach crocodile clip to one end of pencil graphite
Free end



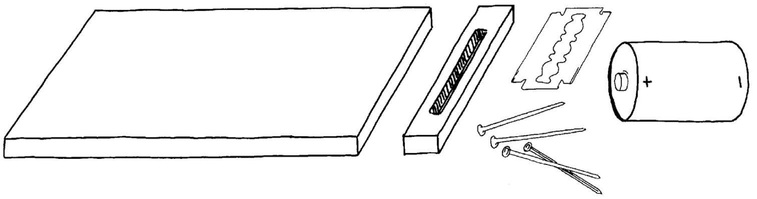
Slide Free End on Pencil Graphite.
The bulb will LIGHT UP
and its intensity will change!



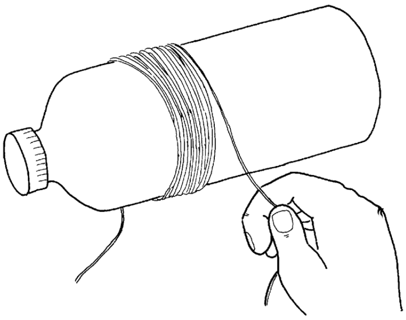
With short GRAPHITE in series
(meaning less resistance)
the bulb will be BRIGHT.
With longer GRAPHITE in series
(meaning more resistance)
the bulb will be DIM.

13. MAGNETISM FROM ELECTRICITY

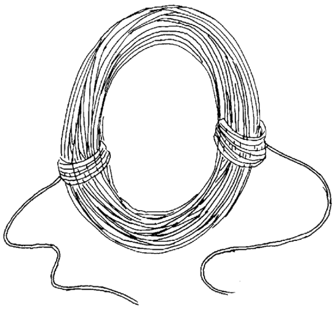
When an electric current flows through a coil it becomes an electromagnet and can align a blade in the direction of the magnetic field.



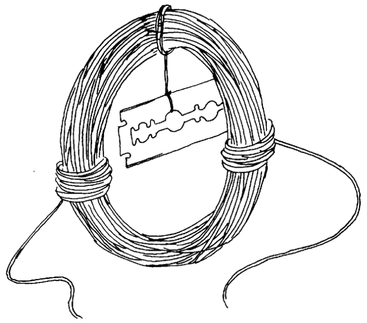
1. You will need a wooden board, a wooden strip with a cut in it, an old shaving blade, nails, 1.5-volt battery, 20-gauge insulated copper wire (used for motor rewinding) and ordinary hand tools.



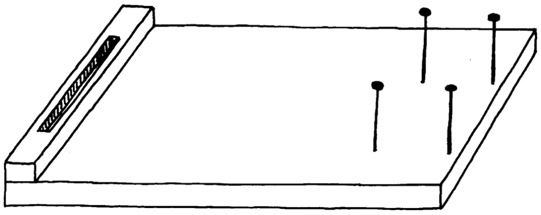
2. Wind 50 turns of 20-gauge copper wire on an old plastic water bottle.



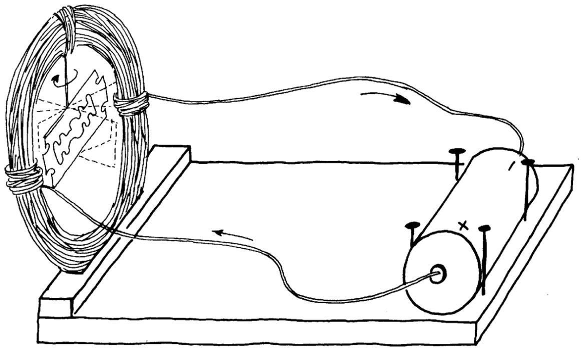
3. Tie the two ends to anchor the loops of the coil. Scrape the ends of the coil to expose shining copper.



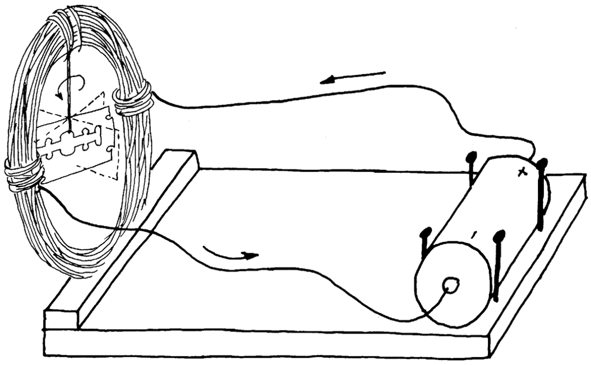
4. Hang a used shaving blade with a thin thread as shown. The blade should be aligned parallel to the coil.



5. Prepare the wooden board as shown. Stick a wooden piece with a cut section to hold the coil. On the other end hammer four nails to hold a 1.5-volt battery in place.



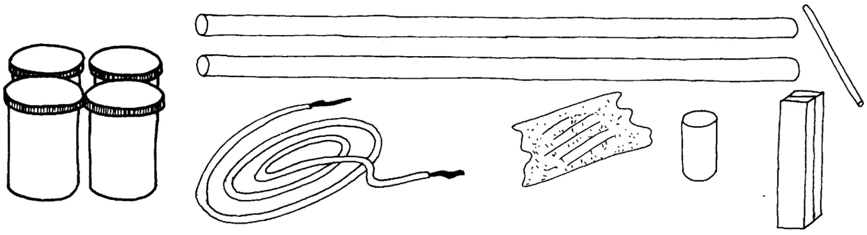
6. Now connect the copper ends of the coil to the battery. The hanging blade which was parallel to the coil will turn at right angles to the coil in one direction.



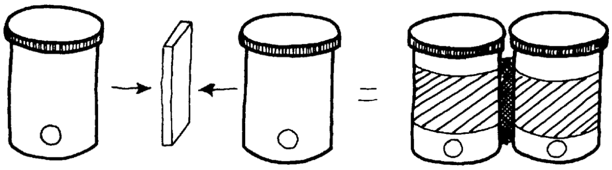
7. Now reverse the terminals of the battery. Again connect the copper ends of the coil to the battery. The hanging blade will once again turn at right angles to the coil but in the other direction.

14. MAGNETIC RAIL

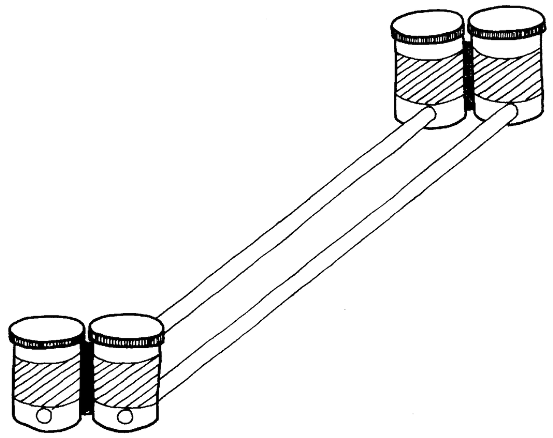
In this magnetic rail a copper rod rests on two aluminum rails through which current flows. As you bring a strong magnet behind the copper rod it starts to move!



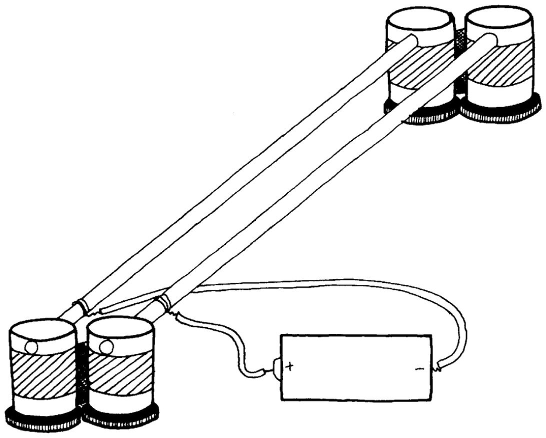
1. You will need 4 film roll bottles, two aluminum rods (30-cm long, 8-mm diameter), one 5-mm copper rod (6-cm long), electric wire, 1.5-volt battery, thin rubber, adhesive, sandpaper and some hand tools.



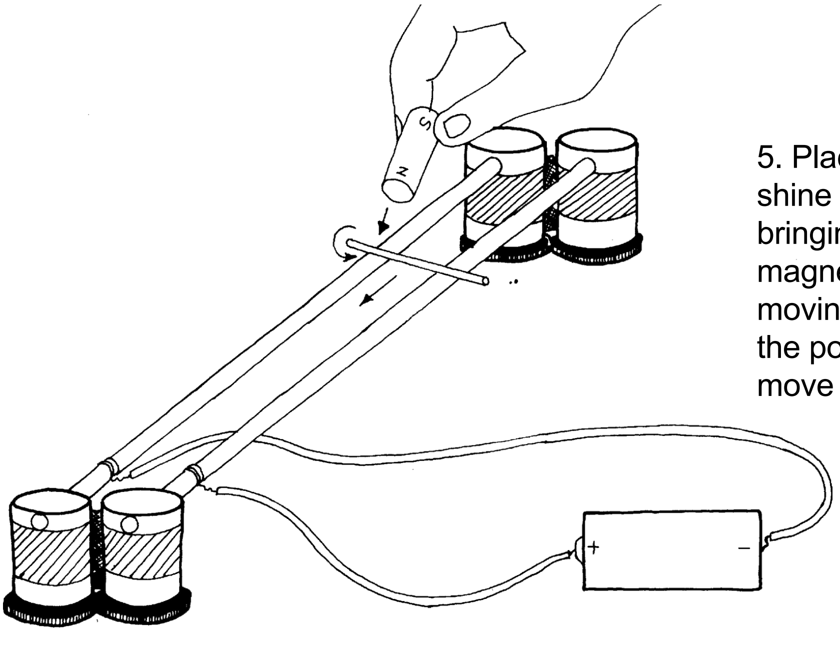
2. Make 8-mm holes in the four film roll bottles. Join two bottles with adhesive and a thin rubber in between. Make two such pairs.



3. Press fit the aluminum rods in the film bottles to make the rail track.

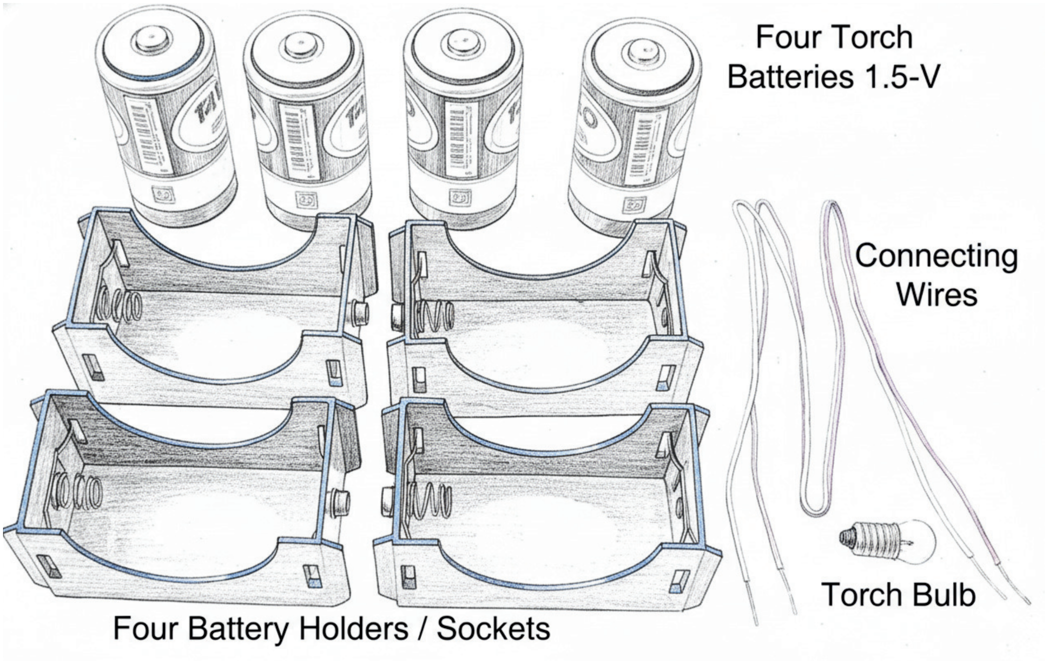


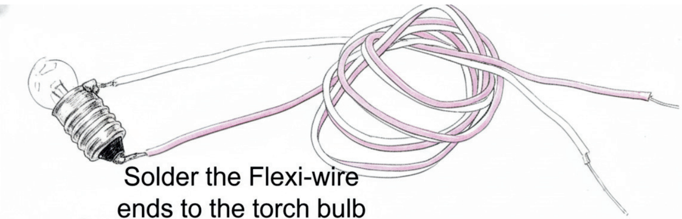
4. Sandpaper the ends of the elecric wire and connect the two aluminum rods with a 1.5-volt battery cell as shown.

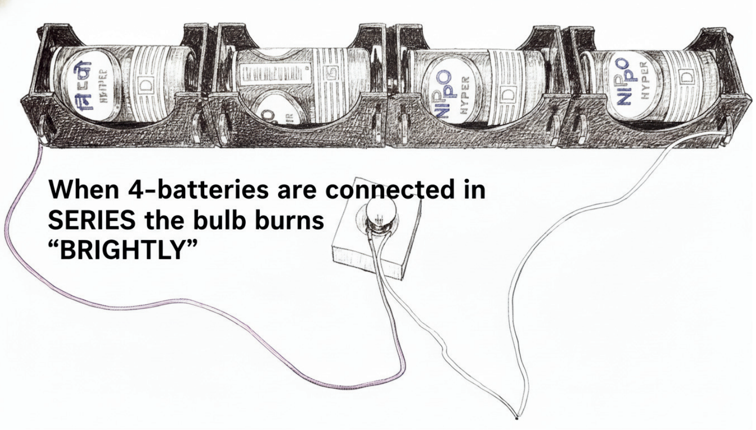


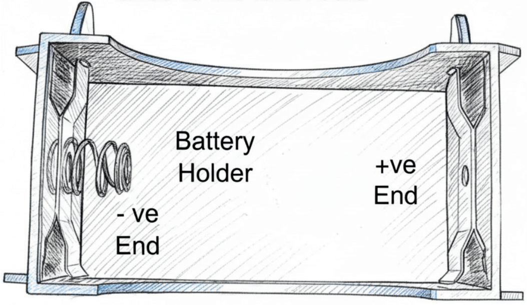
5. Place the Copper rod after making it shine with the sandpaper on the rails. On bringing a strong Neodymium (rare earth) magnet behind the Copper rod it will start moving on the aluminum rail! On changing the polarity of the magnet the rod will move in the opposite direction.

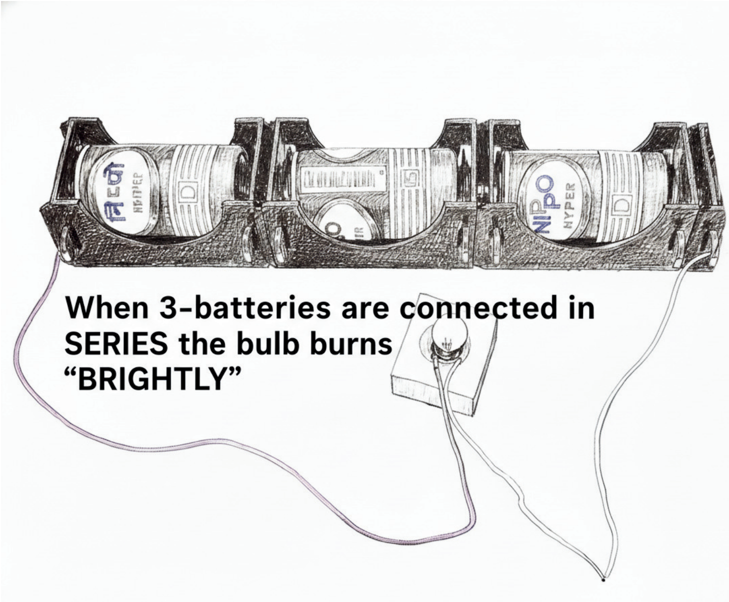
15. SERIES & PARALLEL

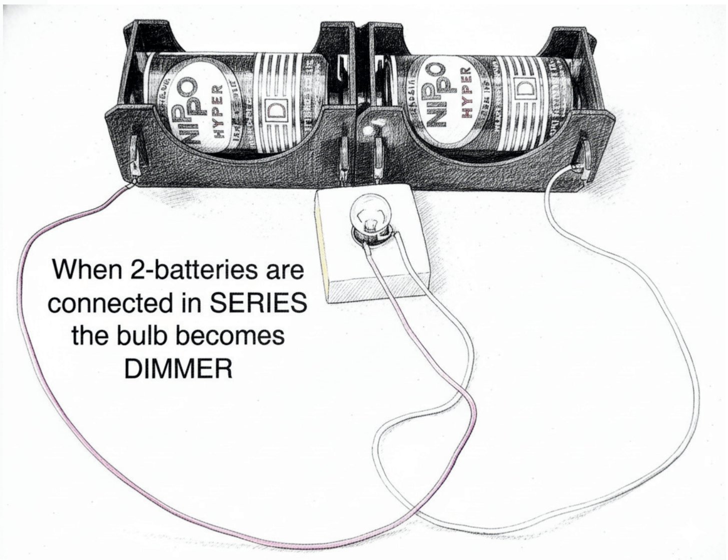

Four Torch Batteries 1.5-V
Connecting Wires
Torch Bulb
Four Battery Holders / Sockets

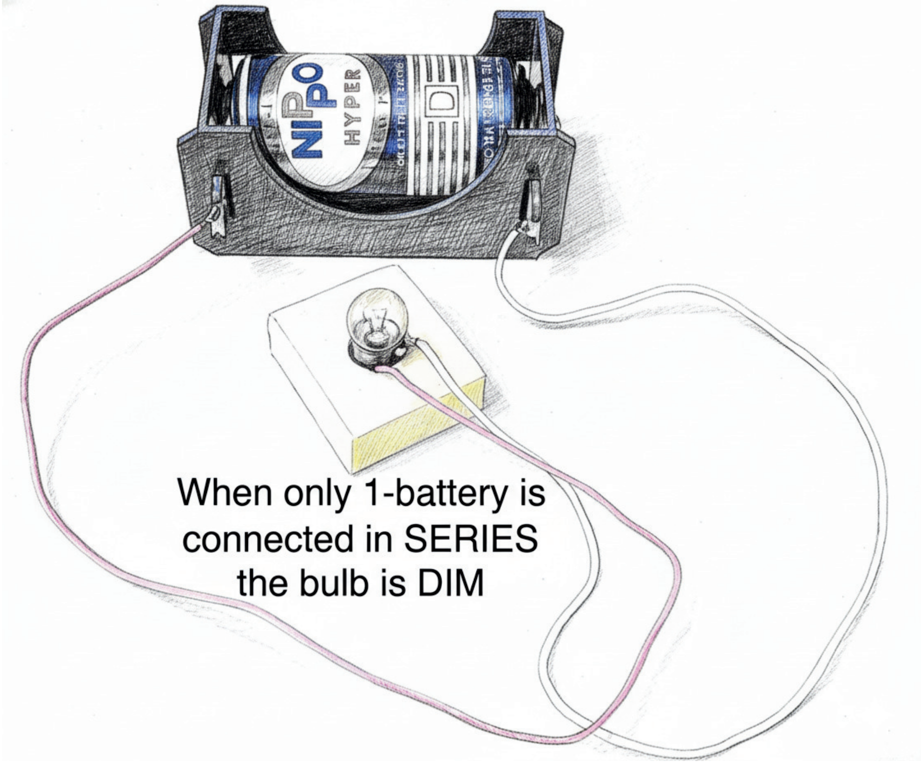

Solder the Flexi-wire ends to the torch bulb


When 4-batteries are connected in SERIES the bulb burns "BRIGHTLY"

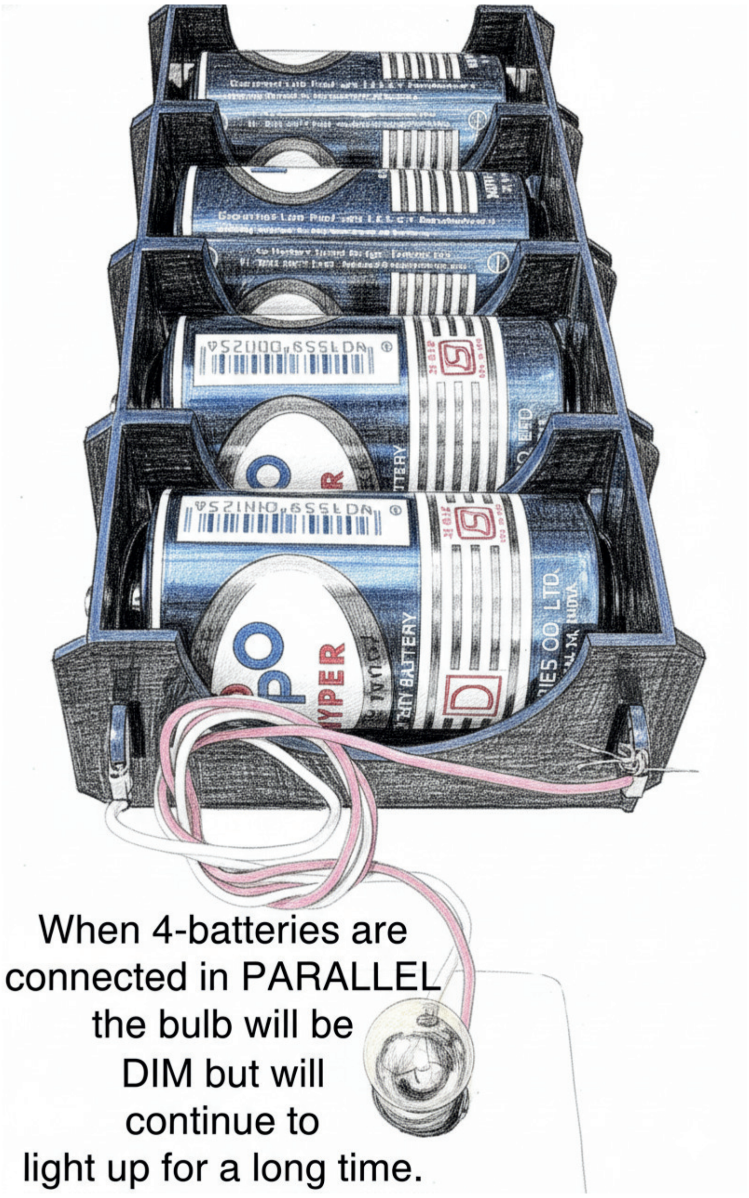

Battery Holder
+ve End
- ve End


When 3-batteries are connected in SERIES the bulb burns "BRIGHTLY"


When 2-batteries are connected in SERIES the bulb becomes DIMMER

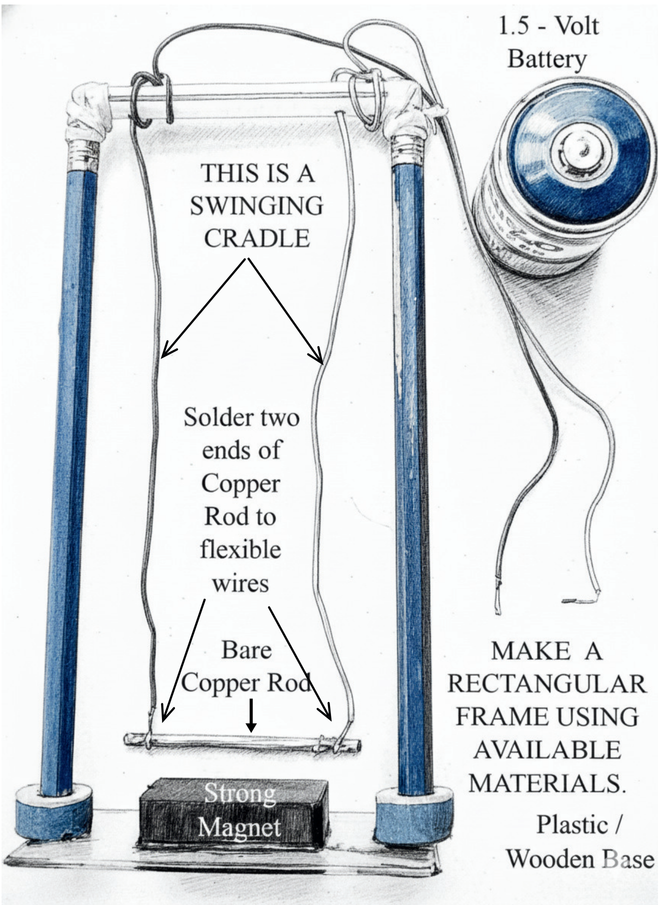

NIPPO
HYPER
D

When only 1-battery is
connected in SERIES
the bulb is DIM


NIPPO
HYPER
D

When 4-batteries are
connected in PARALLEL
the bulb will be
DIM but will
continue to
light up for a long time.

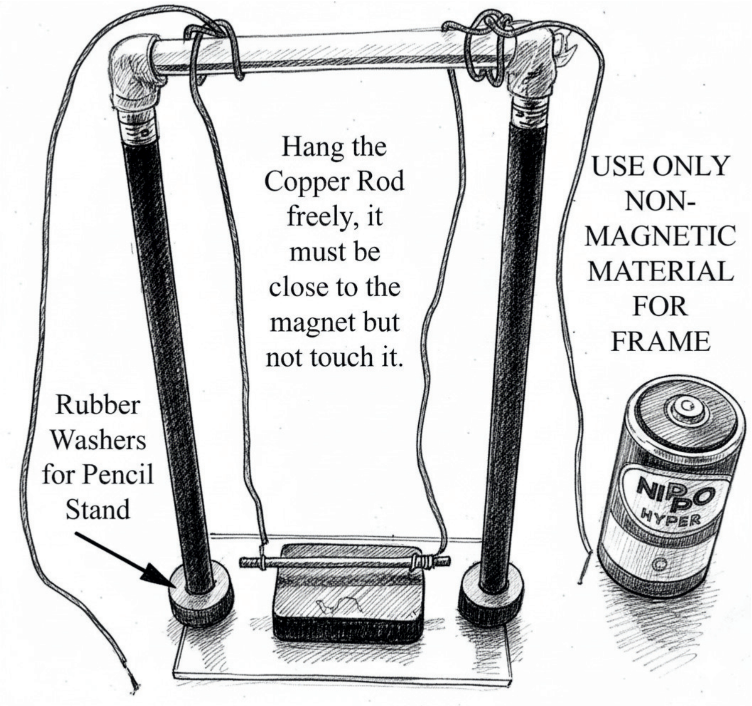
16. FLEMING'S LEFT HAND RULE
(ELECTRIC SWING)


1.5 - Volt Battery
Bare Copper Rod
Strong Magnet
Plastic / Wooden Base

THIS IS A SWINGING CRADLE

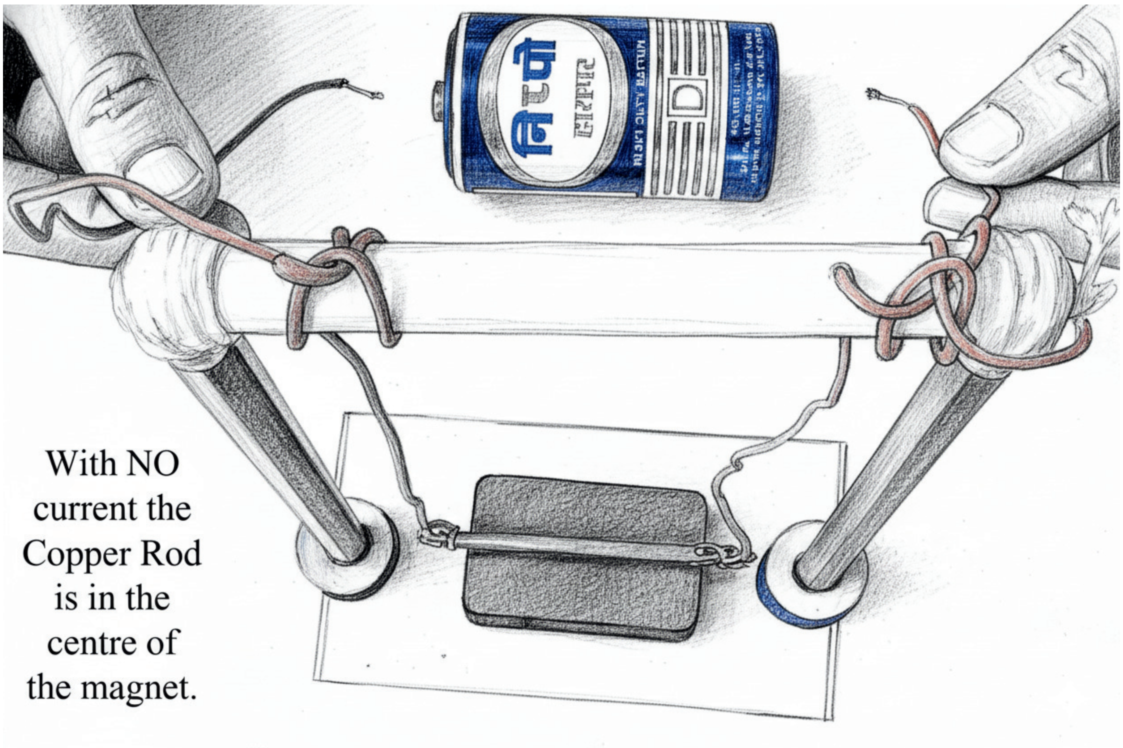
Solder two ends of Copper Rod to flexible wires

MAKE A RECTANGULAR FRAME USING AVAILABLE MATERIALS.

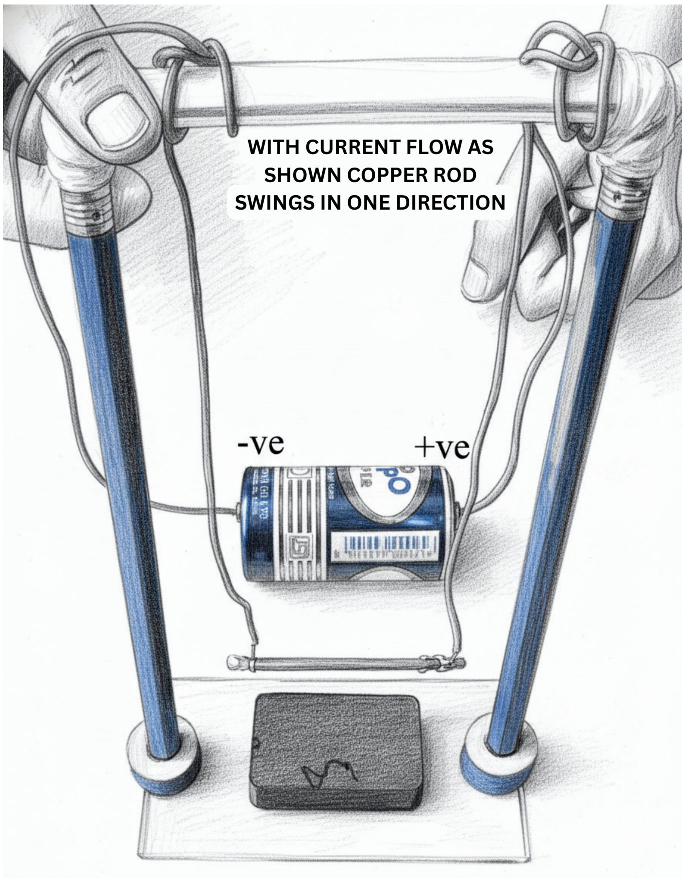

Rubber Washers for Pencil Stand
NIPPO
HYPER

Hang the Copper Rod freely, it must be close to the magnet but not touch it.

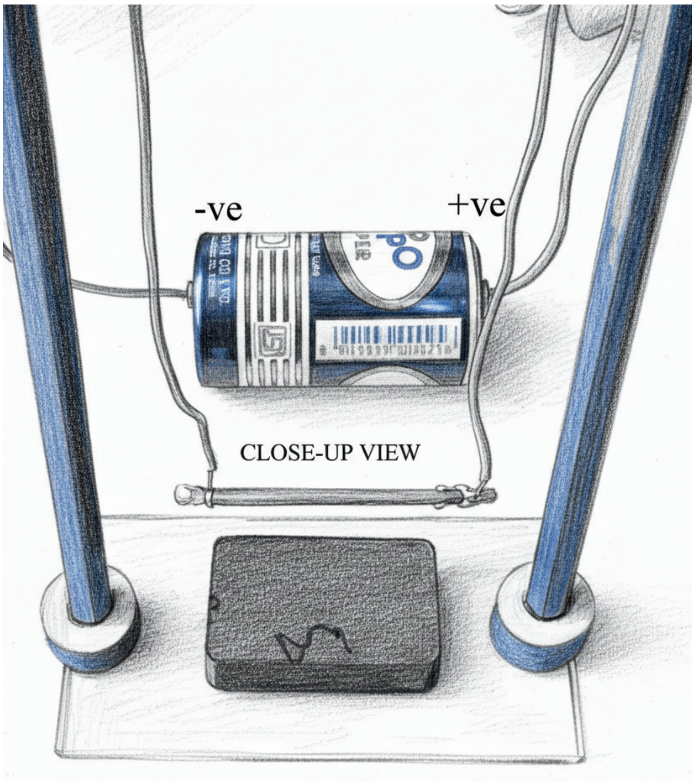
USE ONLY NON-MAGNETIC MATERIAL FOR FRAME



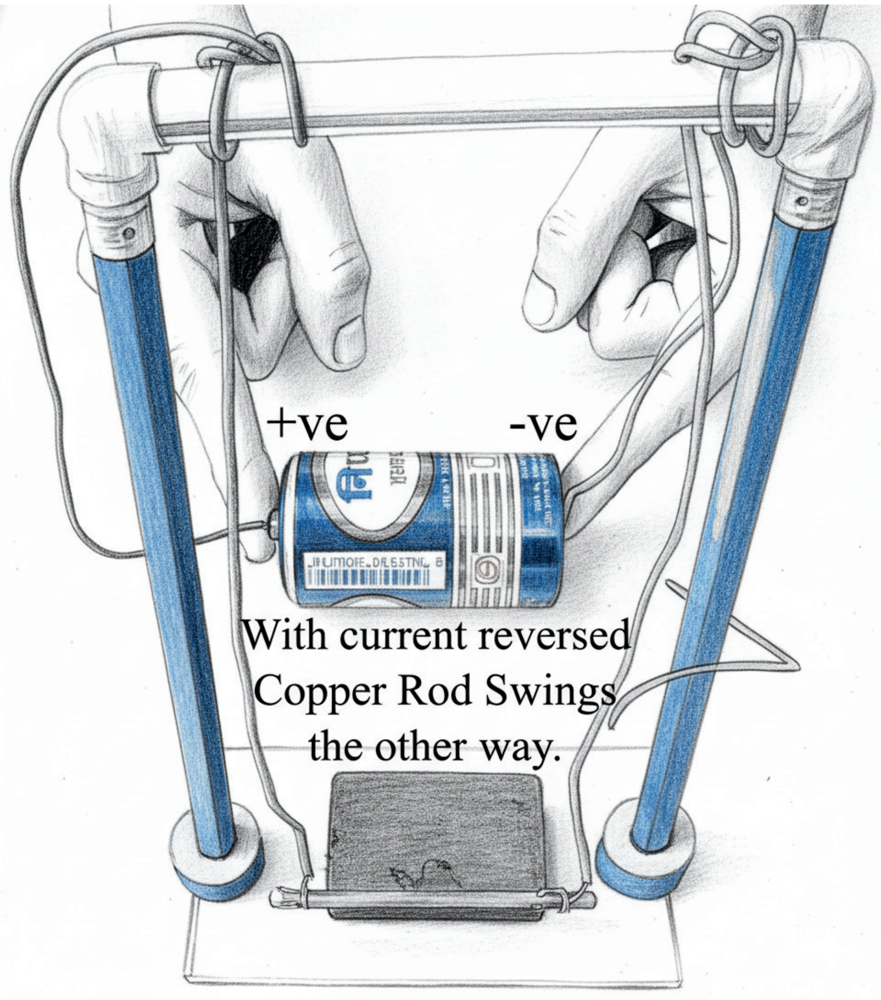
With NO current the Copper Rod is in the centre of the magnet.



WITH CURRENT FLOW AS SHOWN COPPER ROD SWINGS IN ONE DIRECTION

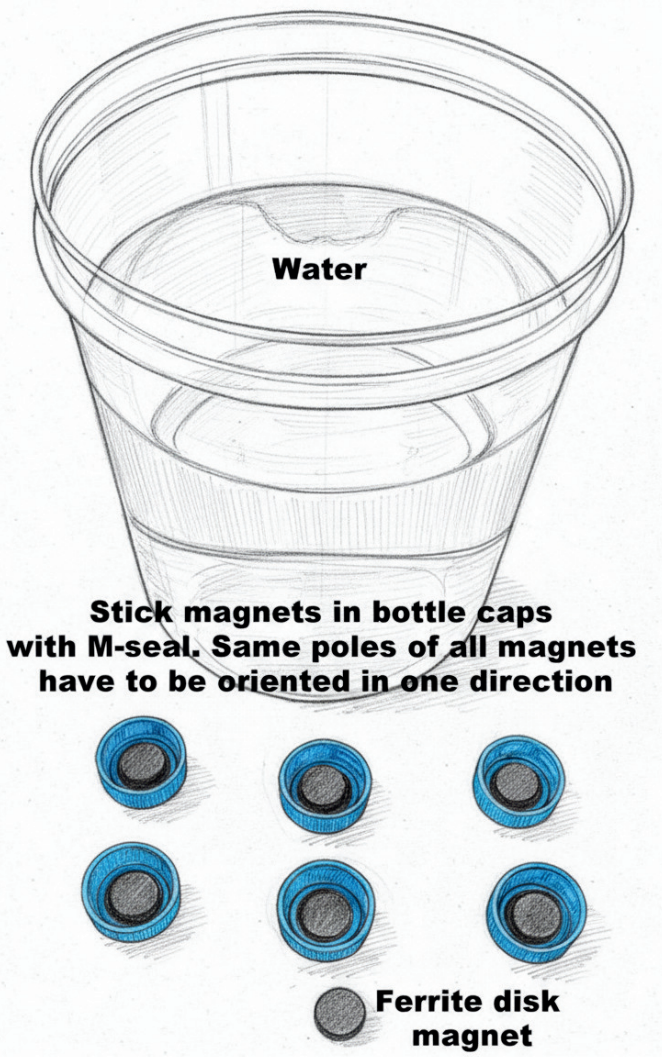


CLOSE-UP VIEW

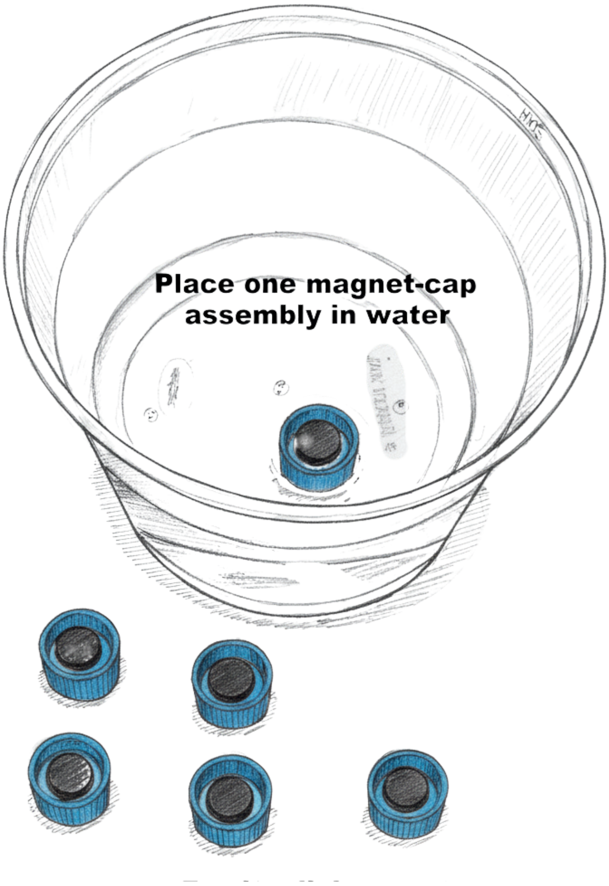


With current reversed Copper Rod Swings the other way.

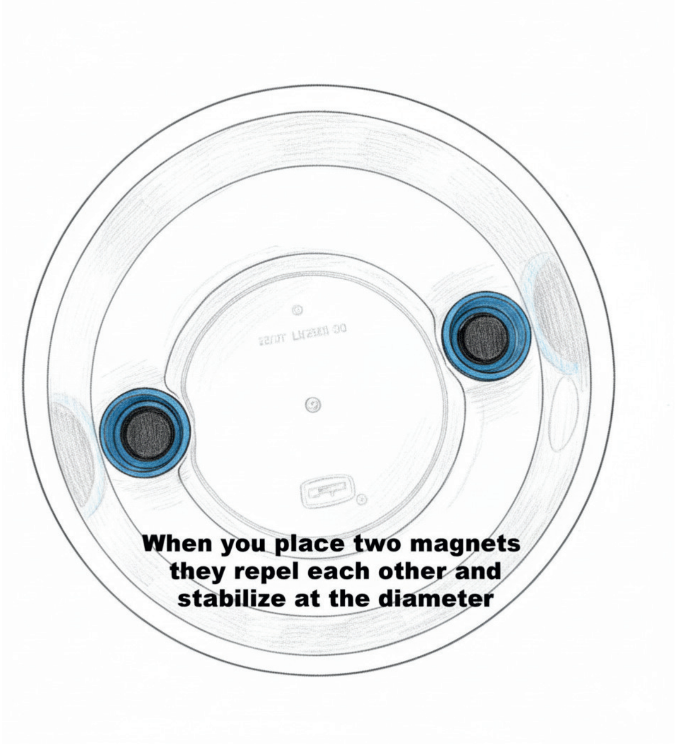
17. GEOMETRY WITH MAGNETS



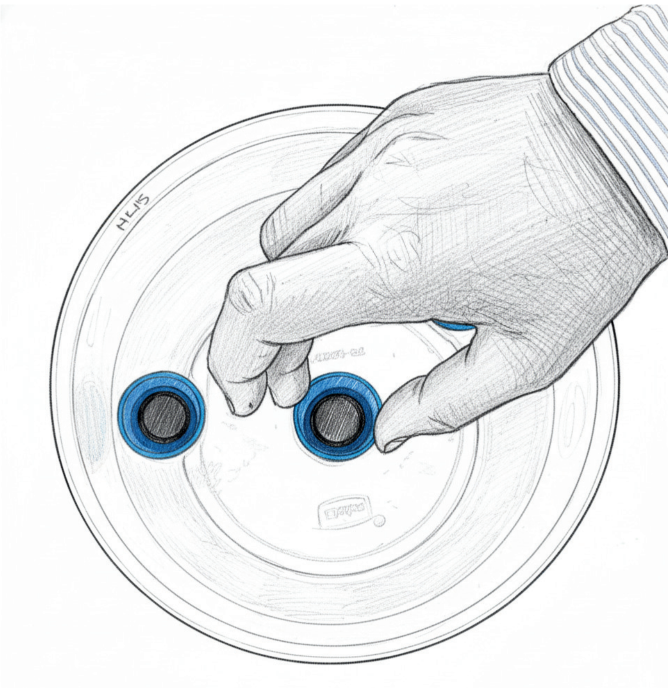
Stick magnets in bottle caps with M-seal. Same poles of all magnets have to be oriented in one direction



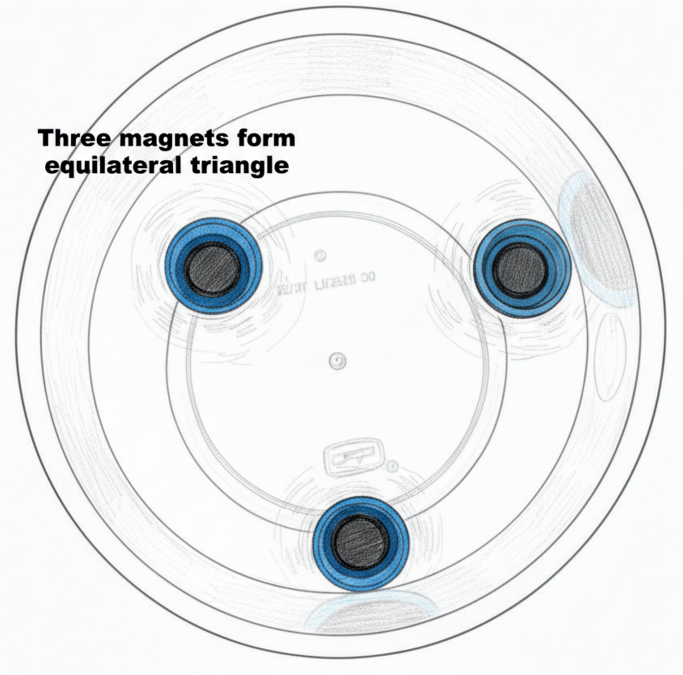
Place one magnet-cap assembly in water



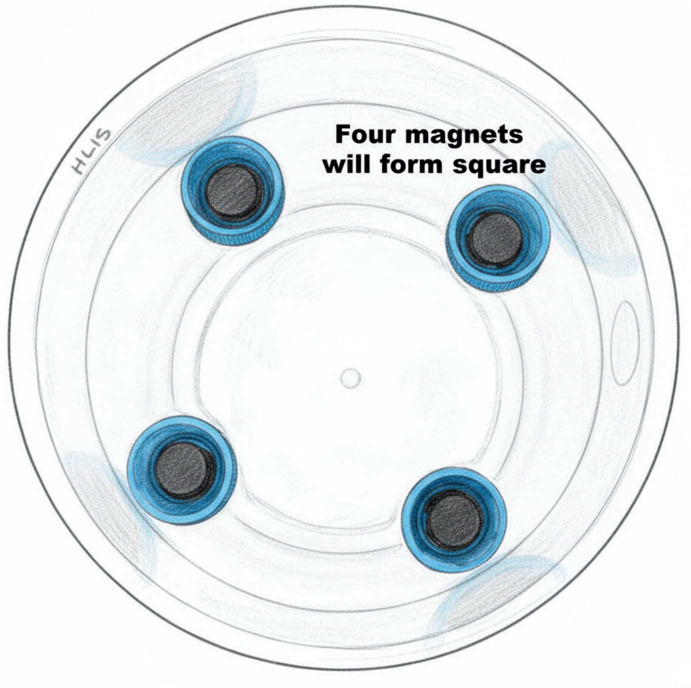
When you place two magnets they repel each other and stabilize at the diameter



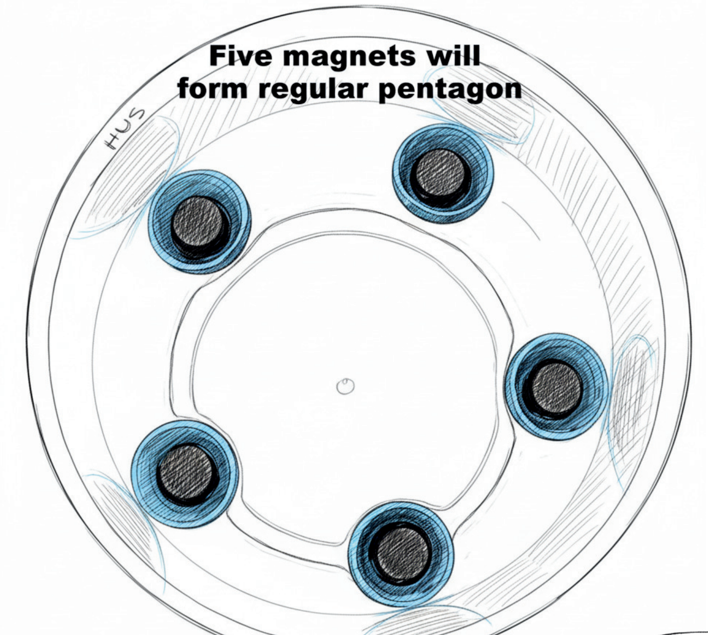
Place third magnet



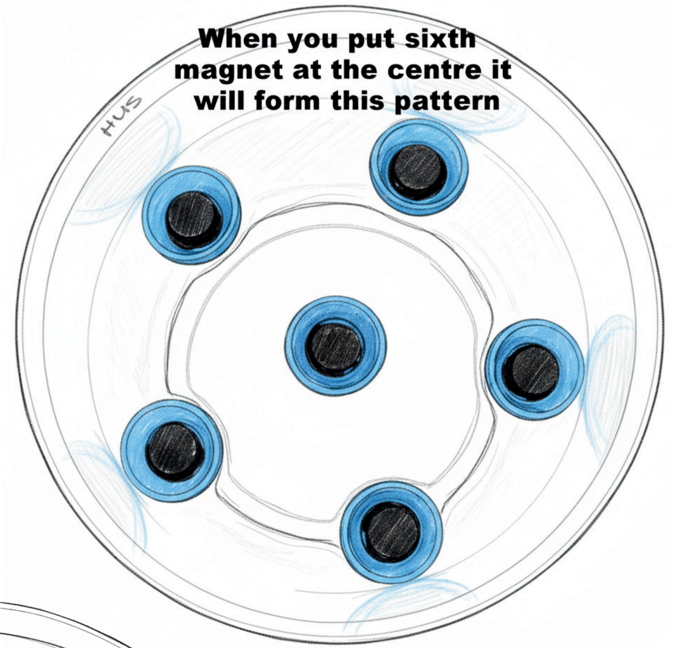
Three magnets form equilateral triangle



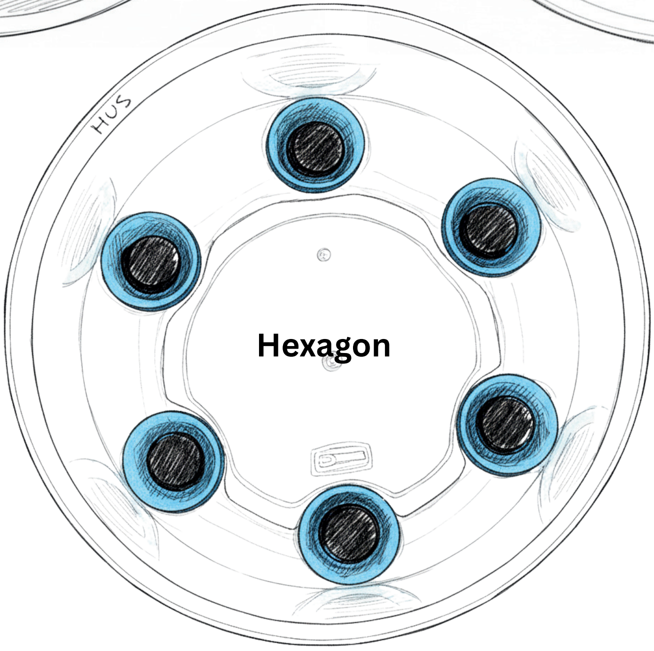
Four magnets will form square



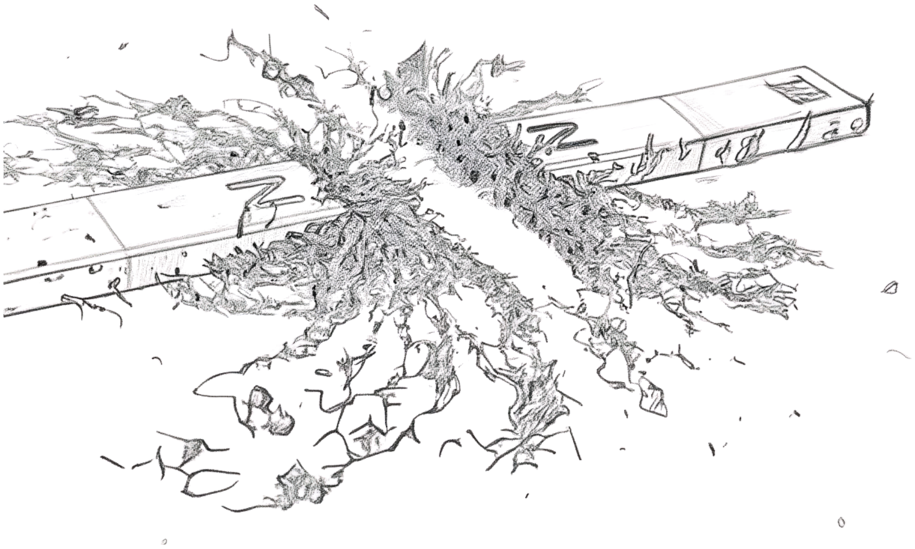
Five magnets will form regular pentagon



When you put sixth magnet at the centre it will form this pattern



Hexagon



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2. BOOK OF EXPERIMENTS: ELECTRICITY & MAGNETISM
3. BOOK OF TOYS: TOYS THAT FLY
4. BOOK OF PAPER FOLDING: CREATIVE ORIGAMI